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HIGH-LEVEL NUCLEAR WASTE MANAGEMENT

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OVERSIGHT HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT

OF THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS HOUSE OF REPRESENTATIVES

NINETY-SEVENTH CONGRESS

SECOND SESSION

ON

HIGH-LEVEL NUCLEAR WASTE MANAGEMENT

HEARING HELD IN WASHINGTON, D.C.
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HIGH-LEVEL NUCLEAR WASTE MANAGEMENT

THURSDAY, JUNE 17, 1982

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT,
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:45 a.m., in room 1324, Longworth House Office Building, Hon. Morris K. Udall (chairman of the subcommittee) presiding.

The CHAIRMAN. The Subcommittee on Energy and the Environment will be in session.

The subcommittee has convened this morning to review the status of our Federal programs for development and regulation of permanent repositories for high-level nuclear waste.

The Interior Committee has made enactment of legislation to establish a decisionmaking track for these disposal facilities the top priority in the remaining months of this Congress. The Senate has passed legislation compatible with our committee recommendation, and the House Science and Commerce Committees are cooperating in nuclear waste legislation. The nuclear industry, the administration, Congress, and the public are intensely interested in seeing a legislative decision made with respect to these nuclear waste issues. I am a believer in the critical need for a mandated waste policy. But we are here today in recognition that the most completely detailed and broadly mandated policy we can put on the books will not produce for us an operating waste repository if we don't pay diligent attention to making sure that the agencies entrusted with the responsibilities are fulfilling them in a thorough and timely manner.

The proper role of the Congress—and one we have attempted to play in formulating a nuclear waste policy—is to set up a framework and a time schedule for decisions that must be made and activities that must be accomplished by the agencies. Some of the testimony presented today will bring us up to date on current plans and technical issues which will be important to us as we round the bend of final decisionmaking on our nuclear waste legislation. These issues include the schedule for completion of major technical tasks, and the appropriate testing and operation phases for development of repository sites.

Once these mileposts are in place, it will take clear, focused effort and maximum cooperation on the part of the Federal agencies if they are to be met. We want to begin now to make sure that the constant slippage and delay that has plagued our waste program in the past does not ambush us again. If there are problems

in the waste management programs, we want to identify them early and get back on track. In this regard, I have a few concerns about our programs on which I would like to receive some feedback.

First, the Department of Energy has sent some mixed messages on the repository development schedule, indicating in news accounts that it planned to "fast-track" certain investigations and speed up the schedule, but releasing schedules to NRC and at briefings for congressional staff showing varying speedups and delays. DOE today is officially representing its schedule as not having changed, at least since December 1981. What started out as an effort to compare schedules to see whether we were getting ahead or falling behind leads us instead to begin questioning what relevance these estimated schedules have to actual technical work being conducted in the field, which seems unlikely to produce the kinds of accelerations and slowdowns coming through to us here in Washington.

It is important in setting target dates for repository development that we keep the program moving quickly, without cutting off important technical work, or setting dates so unrealistic as to build failure into the program. I hope we can get a feeling today for some of the technical requirements and constraints that should be considered in setting these development goals.

I am also concerned that the Department of Energy and the Nuclear Regulatory Commission cooperate in determining what information we need, and in making sure that the right information is collected, so that the licensing process can proceed as smoothly as possible. Recent comments by Commissioner Ahearne before the Commerce Committee, and an exchange of correspondence between the Commission staff and DOE staff, have indicated there may be some communication problems between the agencies which need attention.

The Commission and the Environmental Protection Agency both have responsibilities in developing standards and safety objectives for the repository. Although the NRC has set forth some of the general guidelines and completed licensing procedural requirements, certain important operational criteria have yet to be promulgated. The Environmental Protection Agency's general standards for the repository which are critical to certain technical planning and design decisions are long past due. We would like an update on the progress on these regulatory tools and an indication of any problems which might arise in the program as a result of their absence.

That concludes my opening statement.

Mr. Marriott, do you have any comments?

Mr. MARRIOTT. Yes, Mr. Chairman.

The CHAIRMAN. The gentleman from Utah is recognized.

Mr. MARRIOTT. Thank you, Mr. Chairman.

I am also pleased to be able to participate in today's hearing on the present ongoing activities of the various Federal agencies and departments concerning the management of high-level nuclear waste. We have been working toward a solution of this problem now for the past 20 years, and it is now imperative that we establish a clear direction for the management of these wastes.

Roughly, 7,000 metric tons of spent uranium fuel are presently stored in commercial reactor sites in the United States. Additions to these stockpiles are projected to exceed capacity at numerous sites in the next several years, and public skepticism about the Federal Government's ability to deal with the waste problem has almost brought the nuclear industry to a standstill. We must move forward with a sound repository program, and much of the work completed to date has laid a sound foundation for the decisions yet to be made.

Nevertheless, I feel strongly that future nuclear repository activity should take place within the context of legislation now being considered by both the House and the Senate. These bills will provide the appropriate safeguards and assurances necessary to restore public confidence and assure the long-term health of our citizens.

In the absence of final legislation on the nuclear waste issue, I would like to take just a moment, Mr. Chairman, to express some concerns I have regarding the present activities of the Department of Energy and others.

No. 1, I am deeply concerned about the procedures followed by the Department of Energy in examining the different geological media for potential as a permanent repository. First of all, it is unclear to me what the position is regarding salt, tuff, basalt, and granite as the best prospect. Any drilling or testing at this point, I assume, is only to address those problems. I hope we are not just going through the motions with the die already cast.

For example, I hear very little talk about granite, very little discussion about tuff, very little discussion about basalt, and it appears to me that we are keying in on the salt formations. Many of our constituents are concerned that, if we in fact have already written off on salt, they ought to be advised about it.

In Louisiana, for example, they have salt domes above the ground which are on private land. In Mississippi, they have salt domes above the ground which are on private land. In Texas, it is bedded salt, as I understand it, on private land. Within the State of Utah, it is bedded salt on public land. It seems to me that people are assuming that, if we are going with salt, Utah has already been selected. I would like to hear from the Commission today as to whether or not that is fact or fallacy.

No. 2, I am concerned that premature decisions might prejudice a site or medium before all of the data has been collected. We should not be sinking shafts in only one area or holding hearings in only one area. As I understand it, all 10 sites and all 4 media are or should be under consideration. I would like to have the Commission discuss that situation if they could.

No. 3, I am concerned about adequate care and safeguard of the environment. I am somewhat puzzled as to whether or not we plan to do an EIS before a shaft is drilled, or simply an environmental assessment. It seems to me that, since no shaft is to be drilled until September 1983, there is adequate time to determine in advance whether environmental issues would disqualify a site prior to the expensive drilling process.

Fourth and finally, I also strongly urge a close cooperation between the Federal Government and the local communities and the

States. We have received quite a few complaints from State and local officials that adequate cooperation is not there, that the frankness with which they need to discuss this issue is being withheld. Since drilling will cost $30 to $50 million and, since under most of these bills, a State has some veto rights, it is important to deal with the State and local communities up front in an open and frank way with adequate local input. The absence of such input will ultimately result in future chaos and expenditures without any hope of a site being approved.

It is imperative, Mr. Chairman, that legislation pass in this Congress. This will give us the guidelines and the protections to make the waste disposal program workable and acceptable and to restore the public faith in Congress in dealing with the high-level nuclear waste problem.

I look forward, Mr. Chairman, to hearing the testimony here today, and for a frank and candid discussion of these issues and questions.

The CHAIRMAN. I thank the gentleman.

Is there anything further before we proceed with testimony?

Mr. VENTO. Mr. Chairman?

The CHAIRMAN. The gentleman from Minnesota?

Mr. VENTO. I have no prepared statement, but I think these are important hearings so that we can learn how the various agencies are working together. I hope that, in the testimony today, we will not find some voids or some black holes in terms of the various Commission and agencies with respect to the responsibility of dealing with high-level waste.

I think it is important, especially for us, in these proceedings that we are all using the same ground rules in terms of policy we are establishing with respect to high-level waste and the disposal of the same and the protection of the environment.

So I hope, as we look over the record of the testimony, we will find a consistency, though I suspect we will find perhaps some overlap, and we will hopefully not have any voids in terms of this issue. I think it is difficult enough for us, and one of the reasons I think we have that difficulty is because of the inconsistency sometimes of various agencies of government and experts pulling on this issue. We know that there will not be an absolute limitation of that, and differences of opinion will be understood. But when we are talking with respect to government, we look for some consensus with respect to this issue so that we can predicate our policies on and, as I say, that we are using the same ground rules.

I have to leave, Mr. Chairman, but I do intend to be back to hear some of the testimony. I commend you for focusing on this issue at this time. I think it will be helpful to us.

The CHAIRMAN. Mr. Lujan.

Mr. LUJAN. Mr. Chairman, I want to thank you for holding this oversight hearing on high-level nuclear waste. The issue of nuclear waste has been one of the continuing concerns of this committee and of this Congress. It is very timely to hold review on the progress and unresolved technical issues of the waste terminal storage program.

With the Energy and Commerce Committee finally showing signs of marking up their waste bill, we are hopefully moving closer to

passing a major Nuclear Waste Policy Act this year. I am sure that today's testimony from the witnesses on the current status of their joint plans for development and licensing of permanent deep geological disposal facilities will prove beneficial to us in finalizing a schedule for the Nuclear Waste Policy Act. If technical progress and interagency cooperation on repository development and licensing can continue, we will surely meet this Nation's need for resolution of the nuclear waste problem.

Mr. Chairman, I arrived a little late, and I don't know if this has been done already, but I certainly would like to welcome Jim Asselstine at his first meeting before this committee. I had the opportunity of being at another hearing where all five Commissioners were present, but I believe this is his first time here. Welcome.

The CHAIRMAN. I am glad the gentleman from New Mexico raised that point. We all join in welcome, and we hope that you will be treated as fairly and kindly over the years as your colleagues.

Our first panel is the Nuclear Regulatory Commission. Chairman Palladino, we would be glad to hear from you. It must be a pleasure for you to be playing with a full deck of cards here. There were times when they didn't even have a quorum.

Mr. Chairman, you may proceed.

[Prepared statement of Hon. Nunzio Palladino may be found in the appendix.]

STATEMENT OF HON. NUNZIO PALLADINO, CHAIRMAN, U.S. NUCLEAR REGULATORY COMMISSION, ACCOMPANIED BY VICTOR GILINSKY, JOHN AHEARNE, THOMAS ROBERTS, AND JAMES ASSELSTINE, COMMISSIONERS AND JOHN B. MARTIN, DIRECTOR, WASTE MANAGEMENT DIVISION

Mr. PALLADINO. Thank you, Mr. Chairman and members of the subcommittee. My fellow Commissioners and I appreciate this opportunity to appear before you today to discuss some important issues for high-level waste management legislation.

Mr. Chairman, before proceeding with my prepared remarks, we would like to say that we are particularly pleased to see the House of Representatives moving closer to floor consideration of waste legislation. We sincerely hope that the years of hard work on your part and on the part of other Members of the Congress and many others will bear fruit before Congress adjourns.

To be responsive to the concerns of the subcommittee, as expressed in your letter of invitation, Mr. Chairman, our remarks today will be structured to address four topics: That of the Commission's readiness to process a repository license application; the prelicensing communication and cooperation between NRC and the Department of Energy; repository licensing schedules; and the Commission's assessment of factors critical to expediting the licensing process.

First, with regard to Commission readiness to process an application, the Commission issued the final procedure portion of our 10 CFR part 60 rule in February 1981, and will be issuing the technical portion in final form this year. There are, however, two gaps in

our preparedness at this point: The lack of a general environmental standard from EPA for high-level waste disposal, and completion of detailed arrangements with the Department of Energy for gaining early and continuing access to site testing information as it is developed.

We understand that EPA's proposed standard is complete and ready for release to the public for comment. We believe the major interested Federal agencies—EPA, DOE, and NRC—have worked out their differences on a staff level on this proposed standard, and we believe it will be fully consistent with the NRC technical criteria now under development for repository licensing. The delay in issuance of the EPA standard leaves uncertain the final release criteria for the repository. We would hope that these critical proposed standards could be issued as soon as possible.

Before discussing our current relationship with DOE, a short explanation of our approach to licensing under 10 CFR part 60 might be useful. The procedural portion of the rule was designed to assure that the information the Commission will need to make site-specific findings for a repository construction authorization will be gathered before the license application is submitted. The Commission avoided placing formal procedural requirements on DOE's program at the site screening and characterization stage, and DOE is free, without formal procedural requirements, to conduct all the necessary activities to characterize the site for licensing, including the excavation of shafts and lateral drifts for testing at the proposed repository.

Because of the unique nature of repository development, many of the issues that will have to be settled for licensing will involve research and site-specific investigations with long leadtimes. The Commission has provided for and urge extensive interaction between DOE and NRC to identify potential licensing issues early and to consult on the programs for resolving them. We do not want to wait until the time of license application to either raise the issues or to work out what is required to resolve them, since this could result in substantial delay.

NRC's ability to conduct a timely and effective license review is largely dependent upon the quality of these consultations with DOE during the preapplication stage.

To put this idea in practice, the NRC staff, in cooperation with DOE, began a series of reviews of DOE activities, both in the laboratory and at the potential repository sites. In the last 2 years, we have completed two thorough reviews of field activities at Hanford, two at Nevada, and two reviews of the salt site screening program. We have also performed reviews of key technical development programs such as geochemistry and waste form. Each review resulted in a report of observations and suggestions, and a briefing of the findings was given to DOE management.

Although these reviews are considered useful by all parties, they were only annual "snapshots" of the site activities based on formal DOE presentations. We have now reached the point where we need access to the data being generated and more frequent interaction as the pace of the national program picks up. This is so we can independently review the data and make suggestions on the direction

of the site investigation programs while they are in the formative stages.

The second topic is communication and cooperation with DOE. The staff reports that its attempts to establish an arrangement with DOE where we can have continuing access to site data early and discuss the direction of site investigation progress have not been entirely successful. Nevertheless, upon learning of staff views on this point, Secretary Edwards and I agreed that we will work together to resolve any difficulties that may exist. Also, the staff recently had a number of discussions with DOE middle management and have been assured that DOE is committed to frequent open consultations. Based on these discussions and continued DOE and NRC management attention, we believe communication will prove satisfactory from here on.

The third topic relates to licensing schedules. Under existing laws and regulations, we estimate that our review of an application for repository construction authorization—CA, as we refer to it—which is a major step in the licensing process, will take 3½ to 4 years. The greatest source of uncertainty is the hearing process, which we estimate will take 1½ years if everything goes smoothly.

The NRC, while maintaining its responsibility for health and safety, will do everything within its statutory authority to expedite the licensing process to meet the 3½-year goal. However, some possibilities for delay are outside the Commission's control. These include the completeness of the DOE application and any unanticipated technical difficulties that may arise from this first-of-a-kind undertaking.

Given the possibilities for delay, we believe that the schedules in H.R. 3809, the bill reported by the Interior Committee, and the May 26 draft bill by Congressman Ottinger are tight, yet believe they are reasonable.

Last, with regard to expediting repository licensing, the Commission believes that a major contribution to expediting the licensing process can be made by taking all necessary steps to assure that DOE's construction authorization application is as complete and well-documented as possible.

Various bills now under consideration in Congress, including H.R. 3809, also help a great deal to expedite the licensing process by focusing the scope of NEPA issues and giving the Commission encouragement to minimize the duplication of DOE activities in this area.

A number of other measures to expedite the licensing process have also been offered in various forms, such as mandatory interim repository licensing. The Commission believes that mandatory procedural shortcuts are not advisable in this first-of-a-kind undertaking.

These remarks summarize NRC's views on the major points of interest to the subcommittee, and our detailed responses to your written inquiries have been provided for the record. In our remaining time, we would be pleased to respond to any additional questions that you may have.

The CHAIRMAN. Thank you for your statement and your cooperation this morning.

Before we begin, do any of the other four Commissioners have any comments or remarks?

[No response.]

The CHAIRMAN. If not, we will get back to you from time to time.

Mr. Marriott, would you like to be first?

Mr. MARRIOTT. I just have one question. First of all, I welcome the Commission, and I appreciate the work that you do.

Your major role won't take place until the 1985-87 timeframe, so it is my understanding that what you are doing now is monitoring DOE, working closely with DOE, getting ready so that, when your time comes, you can expedite the licensing process; is that what we are doing?

Mr. PALLADINO. Yes, it does involve active participation on our part in keeping up to date with the activities that DOE is undertaking, and to make sure that we are getting and evaluating the data and giving feedback to DOE.

Mr. MARRIOTT. You have no formal role to play until that point; is that correct?

Mr. PALLADINO. That is essentially correct. However, we do have considerable consultation in the process.

Mr. MARRIOTT. Thank you.

The CHAIRMAN. Mr. Lujan?

Mr. LUJAN. Thank you, Mr. Chairman.

We had some hearings earlier in the week in another committee on research. What specific kinds of research is NRC doing in connection with the high-level waste and deep geological studies?

Mr. PALLADINO. Our research is primarily concerned with trying to get information on the geotechnical characteristics of various kinds of rock formations or bedded salt, understanding the problems associated with the strength of the rock in which we will finally develop the rooms for emplacement of the high-level waste, and understanding the nature of that rock formation with regard to hydrologic characteristics.

If you would like more specifics, I could call on Mr. Jack Martin, who is Director of our Office of Waste Management.

Mr. MARTIN. Yes. My name is John Martin, Director of the Waste Management Division.

Mr. Lujan, our research program—let me talk a minute about the focus of it, and then I can talk about the four major things we are looking at.

We are probing primarily into understanding what the failure mechanisms might be, and a fundamental understanding of the technical questions involved, as opposed to the DOE research program which is more oriented toward making a product and delivering something that works. We are looking for the weak points. That is the major difference. So you may see two topics that look like they are the same. We are looking at a slightly different aspect than they are.

We are looking at four major areas: The waste form area, which is the canisters and the glass and whatnot, and the weak points, and the things we have to watch out for there; we are looking at the second major topic, which is the repository design itself, the size and shape of the openings and what sort of things to look for there; the third is the more far-field geology and hydrology ques-

tions that some of the witnesses will talk about more later; and last are the analytical methods that you use to project performance into the far distant future.

Mr. LUJAN. Do you have any role at all in doing any research in conjunction with WIPP?

Mr. MARTIN. No, we do not.

Mr. LUJAN. I know you don't get involved in licensing that particular facility, depending on who you are listening to.

Mr. MARTIN. Right.

Mr. LUJAN. But assuming that you don't have to deal with licensing of a military repository, still you do not get involved even in the research, such as consulting with Westinghouse on what they are finding?

Mr. MARTIN. We are aware of what they are doing. We review their reports.

Mr. LUJAN. But you don't have any money in that project?

Mr. MARTIN. No.

Mr. MARRIOTT. Would the gentleman yield?

Mr. LUJAN. Yes.

Mr. MARRIOTT. If I could just follow up on that. Since NRC will be licensing the final repository, what input do you have now in terms of the medium selection? Do you have any input at all into what type of medium is going to be used there? Are you advising DOE? Are you doing any research in that area?

Mr. PALLADINO. It is my understanding the medium will be selected by DOE. However, we expect to provide feedback based on our evaluation of their reports. We will expect a site characterization report from DOE, and then followup semiannual reports from them. We will use these for providing feedback.

Mr. MARRIOTT. But as of this point in time, are you neutral on that issue? Do you have a position as to what medium you think is the best for long-term storage, or are you still neutral on that position?

Mr. PALLADINO. Yes, we are quite open on all of the sites.

Mr. LUJAN. Wouldn't it be productive for you to, after your research, indicate to DOE which one you felt might be a better medium? If you are going to have to license, you are going to look at a particular site. If you have done research on all of the different mediums, then you would have a preference. You would certainly be a stumbling block in approving the one that they chose if you didn't agree that was the best.

Mr. PALLADINO. We certainly would speak to the acceptability of any site. It is possible that all three sites would not be characterized to the same amount of detail at any one particular point. But we would not be silent if we saw that any one of these sites was unacceptable.

Mr. LUJAN. In other words, you wouldn't be playing just a dog in the manger position; you would be consulting with them.

Mr. PALLADINO. Yes. That is why we are paying so much attention to establishing a good working relationship with them, so that we get that detailed knowledge on a continuing basis and on a timely basis.

Mr. LUJAN. Thank you, Mr. Chairman.

The CHAIRMAN. Chairman Palladino, Professor Witherspoon of Lawrence Berkeley Laboratory will be here later this morning on another panel. He has advocated use of an existing mine to conduct certain generic tests to confirm testing methodology and to gather other generic information. Are you familiar with this proposal, and do you have any comments on its advantages or disadvantages?

Mr. PALLADINO. I have heard about the desirability of doing some generic testing. It is my understanding that the testing that has to be done is so site-specific that it is very difficult to make any generalizations based on a generic type of review. That even goes to the extent of the measurement techniques. However, I think the measurement techniques could and should be tested in the kind of rock formation that is found at any of these sites so that the measurements that are taken can be assessed in terms of precision and accuracy after they are obtained in the field.

I don't know if Mr. Martin or any of my fellow Commissioners have any additional comments or not.

Mr. MARTIN. We feel that the kind of testing that you mentioned is desirable. However, given the fact that we have limited time and funds to do this, it seemed to us it would be a better idea to do it at the sites being characterized. DOE will talk later about how they plan on having some test facilities at at least three sites. We feel that it would probably be best to do the types of tests and development at those sites.

The CHAIRMAN. While you are standing, let me follow this on. Where in America, or where in the other nations that are working on this nuclear waste problem, do we have the longest tests? We were in Nevada down in a shaft where they were running some tests with heaters and all of this. Where, there or elsewhere in the world, have we had the most testing now with heaters and this kind of thing? Are we ahead of everybody else?

Mr. MARTIN. I think that probably the facility in Sweden—Stripa is the name of it—has the longest track record. DOE has been doing tests, of course. There were a lot of tests done in Lyons, Kans., that were discontinued. They have been doing a considerable number of tests in salt formations and——

The CHAIRMAN. Can we expedite this thing by going into some old mines and seeing what happens in rock or whatever is available there?

Mr. MARTIN. We would still be left with the question of what relevance is that data to some other site over here. I think we just get all tangled up trying to bridge that gap. In our view, the best way to spend our research money has been to take advantage of the site characterization facility that will be built anyway and do it there.

The CHAIRMAN. What is the difference between these generic tests and the TEF which the Commission says should not be at a repository site?

Mr. PALLADINO. Mr. Martin indicates that what we believe we said is that the T. & E. facilities should be at the site where characterization has taken place.

The CHAIRMAN. All right. We have a lot of ground to cover today.

Mr. Asselstine, do you want to make some penetrating pronouncement on this important occasion?

Mr. ASSELSTINE. I don't think so, Mr. Chairman, other than I certainly agree with the comments that have been provided by the Chairman.

The CHAIRMAN. I am pleased. I think this hearing has helped us focus attention and in getting people talking to each other. I am determined to get a bill this year. I am probably going to have to go to the leadership next week unless some things begin to move and try to expedite it. It is important. I think this hearing today will help us keep the pressure on and make it possible to keep an accelerated schedule once we get this bill passed.

We thank you very much for being here today.

Mr. PALLADINO. Thank you, Mr. Chairman.

The CHAIRMAN. Our next panel is Dr. Thomas Dillon, Deputy Assistant Secretary for Nuclear Energy, DOE; and Dr. Franklin Coffman, Acting Director, Office of Terminal Waste Disposal and Remedial Action, Department of Energy.

Dr. Dillon, you may proceed.

[Prepared statement of Hon. Thomas A. Dillon may be found in the appendix.]

STATEMENT OF HON. THOMAS A. DILLON, PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR NUCLEAR ENERGY, U.S. DEPARTMENT OF ENERGY, ACCOMPANIED BY FRANKLIN E. COFFMAN, ACTING DIRECTOR, OFFICE OF TERMINAL WASTE DISPOSAL AND REMEDIAL ACTION PROGRAMS

Mr. DILLON. Mr. Chairman and members of the subcommittee, I am pleased to appear before you today to discuss the Department's progress and plans with respect to the development of permanent deep geologic disposal facilities for high-level nuclear waste. I am accompanied by Dr. Frank Coffman, who has programmatic responsibility for these activities.

With your permission, Mr. Chairman, I will confine my remarks to addressing briefly the concerns identified in your letter of May 28, and submit a lengthier and more detailed statement for the record. I will, of course, be pleased to clarify or elaborate on any area of my statement and to answer any questions you may have.

With regard to the Department's intent to collect necessary and appropriate data to support repository siting activities, we have established a schedule of activities which is described in the Department's position statement in the NRC's waste confidence rulemaking. We have selected candidate sites for detailed characterization on the Hanford Reservation in the State of Washington and at Yucca Mountain at the Nevada test site; specific locations for exploratory shafts at these two sites will be selected in fiscal year 1983. Potential salt sites have been narrowed to areas in Utah, Louisiana, Mississippi, and Texas, with selection of a candidate site and exploratory shaft location scheduled for mid-1983.

Environmental assessments are planned to support the decisions on exploratory shaft locations and proposed detailed site characterization activities. We plan to have available for NRC and State review a site characterization report on the Hanford candidate site by September 1982; on the Nevada test site candidate by June 1983; and on the salt site candidate by July of 1983. Construction of

exploratory shafts is scheduled to begin at the Hanford site by April 1983, at the Nevada site by September 1983, and in salt by April 1984.

While there are no formal approvals or authorizations required by the Nuclear Regulatory Commission for activities associated with site characterization or testing prior to the Department's application for construction authorization, NRC's final rule on licensing procedures, 10 CFR 60, requires the Department to submit the site characterization report. The report will describe the proposed site characterization program, as well as the decision process by which the site was selected and the means used to obtain public, tribal, and State views.

The Commission is required by this same rule to review the report, prepare an analysis of it, and publish its analysis for comment by the general public and by State and local government officials. Following the comment period, the Commission either issues an opinion that they have no objection to the Department's site characterization program, or lists objections and recommendations.

Early NRC involvement in the Department's site exploration and characterization activities can contribute substantially to shortening the repository licensing process. Accordingly, we provide special briefings for the Commission on a regular basis, and encourage frequent visits by the NRC staff to the sites under investigation. The Commission's formal review of the site characterization reports will also provide opportunities for extensive interactions well in advance of an actual license application. We believe this coordination will provide NRC with the type of information required in their licensing deliberations.

There are three findings which the Commission must make under 10 CFR 60 before it can authorize construction of a repository. First, there must be "reasonable assurance that the types and amounts of radioactive materials described in the application can be received, processed, and disposed of in a repository of the design proposed without unreasonable risk to the health and safety of the public." Second, there must be "reasonable assurance that the activities proposed in the application will not be inimical to the common defense and security." And third, that "after weighing the environmental, economic, technical, and other benefits against environmental costs and considering available alternatives, the action called for is issuance of the construction authorization, with any appropriate conditions to protect environmental values."

The kind of tests and information needed to support these findings are basically of two types: One, those which show that the site itself has geologic, geophysical, geochemical, and hydrologic characteristics that will provide adequate isolation of the radioactive material over the long term; and two, those which demonstrate that the design of the repository, waste form, and waste package are adequate to contain the material over the short term.

The first type of requirement we plan to meet by extensive geologic and hydrologic testing at the proposed site, and through the use of models which use data derived from these tests. We plan to meet the latter type by careful design and verification testing. The details of how the Department plans to comply with the require-

ments of the Commission will, of course, be contained in the license application.

We expect to provide NRC with information largely through reports of tests conducted from the surface through boreholes, as well as through the results of in situ tests and investigations conducted during the exploratory shaft program. Such tests reveal the nature of the geology and hydrology of the site, and when used with other data and models can confirm the properties of the rock at the repository depth, the length of time it would take water to travel from the repository to the nearest discharge point, and even the effectiveness of the surrounding rock for retaining radionuclides.

Information will also be provided to NRC in the design documentation for the repository. Drawings will show the size of the rooms and pillars that DOE is proposing for the underground repository, the size of the fans to move cooling air through the repository during the operational period, and other design data. Assessments of the adequacy of the design will also be provided, along with modeling studies of radionuclide transport and results of tests performed on waste containers under expected repository conditions.

In support of licensing and construction, the Department envisions a test and evaluation facility [TEF] that will provide at an early timeframe generic information affecting repository design and operations. This facility could evaluate techniques and confirm the design of the equipment and systems; evaluate performance and establish maintenance and reliability requirements; develop the basis for scaling up to full-scale repository systems; develop and test routine and abnormal operational procedures; and reduce repository design uncertainties.

The TEF, augmenting both site characterization and licensing activities, is included in two waste bills. The Senate bill 1662 would require a site-specific proposal for at least one TEF by January 1, 1983, leading to January 1, 1988 operations. An existing R. & D. site could be chosen for the TEF location, but the TEF must not be physically integrated into the repository. It could receive and emplace no more than 300 packages of high-level waste or spent fuel and, while NRC concurrence must be obtained in the TEF siting, design, construction, and operation, the TEF would not be licensed.

The House Science and Technology Committee bill, H.R. 5016, would require an at-depth TEF to be sited 30 months after initiation of repository site characterization at a candidate location. It would be operational within 88 months after enactment, although construction would not be underway prior to initial repository site selection. DOE and NRC would be required to enter into a memorandum of understanding for review, consultation, and coordination in planning, construction, and operation of the TEF. A similar agreement would be established between DOE and the State or tribal government. An EIS would be required prior to proceeding with in situ tests using radioactive materials, while an EA would be needed prior to excavating major shafts.

This committee's bill, H.R. 3809, as you know, Mr. Chairman, contains no provisions for a TEF.

Turning now to the NEPA process, the Department's nuclear waste management program is structured for full compliance with NEPA. The public draft of the national plan for siting high-level

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radioactive waste repositories and environmental assessment includes a NEPA implementation plan. It is a tiered approach that calls for an environmental assessment for implementing the national siting plan, an environmental impact statement for the test and evaluation facility, and an environmental impact statement for a repository selection.

As for our interactions with involved States, DOE believes that the State governments and the public should have full access to all information regarding its siting activities. When State concerns about substantive and definable issues arise, DOE attempts to work out suitable accommodations so as to address these concerns. Twenty-five grants have been provided to State governments and State universities to permit their independent review of the DOE waste management program and to provide for workshops and public meetings. The Department is also committed to involving the public in the decisionmaking process leading to selection of a repository site. Public review and comment on all major DOE decisions is assured by the Department's implementation of the National Environmental Policy Act.

Finally, let me turn to your question on organization and projected manpower requirements. Based on current reorganization plans, the waste management program will remain a separate entity reporting directly to the Assistant Secretary for Nuclear Energy. In the proposed new organization, the Assistant Secretary will be responsible to the Deputy Secretary for Energy who, in turn, reports to the Secretary of Commerce.

At present, about 700 field personnel—40 DOE and 660 contract—are involved in the initial site characterization program. Between now and the mid-1980's, we project an increase of about 400 positions, 20 of which are for DOE and the balance for contractors. Activities will be managed by a DOE headquarters staff of approximately 75 employees. We estimate a staffing requirement of 15 program personnel to manage the nuclear waste trust fund. Personnel for the remainder of the waste management program, remedial actions, Three Mile Island and West Valley, are not included in these totals.

With your permission, Mr. Chairman, I would like to address a couple of the points you raised in your opening remarks at this time.

The CHAIRMAN. We are going to have to recess for just a moment.

Dr. Coffman, do you have a statement also?

Mr. COFFMAN. No, Mr. Chairman.

The CHAIRMAN. As soon as one of us gets back, we will go to questions. I will be back in 10 minutes or so. I would like to hear what you have to say.

AFTER RECESS

Mr. MARRIOTT [presiding]. The chairman has asked that we go ahead and start the question process, if the DOE panel is still here.

I believe that Dr. Dillon wanted to make some additional comments before we start the questioning process.

Mr. DILLON. I just wanted to address a couple of the concerns that Mr. Udall and yourself, Mr. Chairman, raised in your opening remarks. I think they could take some elaboration.

With regard to the schedule that the Department has for conduct of its program, we do have an approved schedule that has been in place since last year. At this time, we haven't made any changes in the reference schedule. When you look at terms of major milestones for conduct of the repository program, I think the major points are, first, the identification of three candidate sites, second, the selection of a single site as a candidate for the repository, and, finally, the granting of a construction authorization by the NRC to proceed with construction of the repository.

When you look at the schedules and timeframes in the DOE reference plan and compare them to the various bills, you see that, by the time you get to an actual construction authorization, almost all of the bills are 2½ to 3 years ahead of the DOE reference schedule. When you get to the selection of a repository site, you find that the various bills range from 9 months faster than the DOE reference schedule to almost 2 years faster. So these various bills that have been introduced in the Congress represent some acceleration in our schedule.

We have been looking at what it would take to develop a program consistent with all these various bills. But I want to emphasize at this time that until legislative action is complete in the Congress, the DOE has not yet reviewed and approved any form of accelerated schedule. Based on our quick looks at the various bills, the Senate bill S. 1662, your bill H.R. 3809, and the Science and Technology Committee bill H.R. 5016, represent substantial acceleration. We think that the accelerated schedules are feasible.

Mr. MARRIOTT. Most of these bills require, as I understand it, in 1 year after enactment to come up with three sites in three different media. Is that the way you understand it?

Mr. DILLON. Three sites, and we are required by 10 CFR 60 that it be at least two different geological media.

Mr. MARRIOTT. Let me ask you a question on that media business. In my earlier statement, I made the point that we were somewhat unclear about how much enthusiasm you had for some forms of media over another.

Let us take the salt media as an example.

Mr. DILLON. Yes, sir.

Mr. MARRIOTT. There are salt formations in Louisiana, Mississippi, Texas, and Utah. What are your plans now in relationship to testing salt formations? Are you only going to propose drilling in one of those formations, or more than one?

Mr. DILLON. We have been conducting over the years extensive tests in all of these salt formations. We have conducted testing in the Paradox basin in Utah and the Permian basin in Texas to look at bedded salt structures. We have looked at dome salt structures in Louisiana, Mississippi, and Texas.

We do not have, in the case of salt, a candidate for further development as an exploratory shaft. That is a decision that we plan to make next year.

Mr. MARRIOTT. The facts then are that you would not begin any exploratory drilling in any of those places until toward the middle

or end of 1983? Your time line shows somewhere around September of 1983 for salt.

Mr. DILLON. We would make a site characterization report at that time. We actually plan to begin work on an exploratory shaft in the early 1984 timeframe.

The exploratory shaft in salt will lag somewhat behind the exploratory shafts that we now have planned, in basalt and in tuff. That was one of the points that I wanted to make, Mr. Marriott, in response to your concern. Actually, we are a little bit further along on our work in evaluating the basalt and welded tuff. We do have plans to begin exploratory shafts at an earlier timeframe in the Hanford Reservation and the Nevada test site.

Mr. MARRIOTT. The basalt is at Hanford, and the Nevada test site is the tuff; is that right?

Mr. DILLON. It is welded tuff, yes, sir.

Mr. MARRIOTT. Let us suppose that you broke this down to a tuff site, a basalt site, and a salt site, and you put your emphasis on those three media, dissecting the salt issue a little bit more. In my opening statement, I made the point that Louisiana is salt domes on private land, Mississippi is salt domes on private land, Texas is bedded salt on private land; Utah, though, is public land and bedded salt.

Based on the characteristics of those sites, is it true or false that, as a salt site, Utah is a priority spot over the other three?

Mr. DILLON. Right now, our investigations are being based exclusively on the technical merit of the various sites. We have not gotten into considerations of the ease in acquiring the land at all. We are looking at the other land use possibilities and other environmental concerns on a screening basis at this time. We look, first and foremost, at the technical desirability of the various structures. We are still at a stage in the salt investigations where we can't really narrow down.

So, I would have to say that the statement, as you made it, does not really reflect the DOE program.

Mr. MARRIOTT. If that is the case, you have answered the concerns of the State of Utah, the Governor's office and delegation, that just as enthusiastic study and research and exploration on salt formations other than Utah is also going on, and the die has not been cast already. That is the point that we were concerned about.

Mr. DILLON. That is 100-percent correct.

Mr. MARRIOTT. Let me ask you one other question regarding the environmental impact situation. I also indicated in my earlier statement that I thought you were not going to go with the EIS. I think you stated in your testimony that you were going to go with an EA on these sites.

Can you tell us why it is that, since you have got some months to go before you are going to start drilling—at least until September of 1983—in salt, why you don't go with an EIS and get that out of the way once and for all, rather than EA?

Mr. DILLON. Based on the nature of all of the sites—and again, one of our criteria in carrying out our program is to make sure that all of the various media and the various sites get treated in an equivalent sort of fashion—the types of environmental effects that

would be associated with the limited exploratory shaft program do not warrant at this point committing to an EIS.

I want to emphasize, though, that the whole purpose of an environmental assessment is to determine whether or not an environmental impact statement is needed. So the result of an environmental assessment is either a finding of no significant impact, in which case one proceeds, or with a determination to go forward with an environmental impact statement. If, in the conduct of our environmental assessment, even in the middle of it or in the beginning of it, we were to determine that there would be significant environmental impacts, we would then begin the conduct of an environmental impact statement, not only in Utah, but in any site we were considering.

Mr. MARRIOTT. Let us take the Utah site. You plan to have the EA completed by July of 1983.

Mr. DILLON. Yes, sir.

Mr. MARRIOTT. Then you plan to begin the exploratory shaft—if that is what you decide to do—by September of 1983. Are you telling me that between July and September you are still flexible to go with an EIS, that you will make that determination at that point and then go with an EIS if necessary?

The concern that we have is that, after you have gone to the expense of drilling, we don't get into an environmental hassle because we are close to the parks down there, 3 miles off the main park road, and then come back and have to fight the environmental issue. If we have to address the environmental issues, why don't we address them up front? That is the issue that we are concerned about.

Mr. DILLON. That is true. I do want to say that, although we do plan to submit a site characterization report for a salt site in the timeframe that you envisioned, we don't plan immediately to start on construction of the exploratory shaft. That would be some months later. So there is some more time.

But we, in putting out our national siting plan, are taking those factors you brought to bear into account, and are convinced that the schedules that we have allow us to do this. We won't get ourselves in a trap where we aren't able to fully consider the proximity of a national park like Canyon Land fully in our NEPA process.

Mr. MARRIOTT. I want to say for the record that I had some interesting discussions with Dr. Coffman. He has been very good to work with us, given us information, and responded to our needs. We appreciate that very much.

On the other hand, we have received some complaints—as I think you have, too—in another hearing that DOE is not working very well with the States and bypassing some of the channels that ought to be addressed. Can you talk to us about those complaints? I think you are aware of what I am talking about.

Mr. DILLON. Yes, sir. Certainly we are aware of the concerns and complaints that were raised at a hearing last week. We have looked into them. I think as you would suspect, that there certainly is a basis for the concern on both sides. From the perspective of the DOE people, a lot of the concerns and complaints can be traced to misunderstandings and misinterpretations.

However, the way I look at it, and I know the way the Secretary and the Assistant Secretary look at, is that we need to get a cooperative working relationship with all of the States. So perceptions are important also.

I wouldn't want to sit here and try to say who was right and who was wrong. There needs to be more effort to reach a strong working relationship between the Federal officials and the State officials. We are committed to it. I can give you my assurances that we are going to continue to keep pressure on everybody in the Department of Energy associated with this program to do everything possible to cooperate with the States so that they are fully informed and understand what we plan to do. We plan to take into account their concerns and their expertise in helping us carry this program forward successfully.

Mr. MARRIOTT. Your position at this point is that the State criticisms are unfounded, that you do indeed have a good relationship with the States? Let us take the State of Utah specifically because that is where the complaints have come from. Do you, in fact, feel you have a good relationship with the committee that has been established? Are you taking the feedback they give, and so forth?

Mr. DILLON. I think that the testimony indicates that the task force has concerns about their relationships with the Department of Energy. I have looked into the specific allegations that were raised in the testimony and, as you might suspect, I found that there is probably misinterpretation on both sides of the issue.

To me, the important thing to understand is that clearly there is a concern on the States' part and, if they have a concern, we have a concern. We want to work carefully and closely with them. I could go through a list of specifics, Mr. Marriott, which would indicate some of the basic misunderstandings that I think have caused some of these complaints. Probably the more appropriate situation is for us to sit down with the officials of the State of Utah, explain this to them, and to try to alleviate their concerns.

Mr. MARRIOTT. How is the State task force being funded?

Mr. DILLON. The State receives a grant from the Department of Energy to carry out a variety of activities associated with keeping the public informed and allowing for independent State evaluation of DOE activities.

Mr. MARRIOTT. Do I understand, then, that the Federal Government is funding the task force?

Mr. DILLON. I think that the Federal Government provides the bulk of the funds that is the basis for operation of the task force, yes, sir.

Mr. MARRIOTT. That being the case, I assume that the task force has the responsibility of working objectively. Do you find that the task force in most of these States, Utah and others, objective bodies?

Mr. DILLON. They are objective bodies in the sense that they represent the State's interests. One of the phenomena that clearly has been reflected through the entire history of the waste program is a legitimate concern for the States where our research programs and exploration programs are going on. I think that frequently the types of bodies that get formed to help advise the Governor and the State governments on our activities reflect that concern.

Again, I feel that, in many cases, misunderstanding and misinformation develop which can be the source of damage, not only to the Federal program, but I think to the States' interests. That is what we are going to try to work to correct.

Mr. MARRIOTT. I have just one last question at this time. Could you give the committee a brief summation of the comparisons between salt, tuff, and basalt, the advantages and disadvantages of each, and where you are at in terms of looking at those media? Does any one have any strong advantages over any of the others, or are they all in the same basic ballpark in terms of the options?

Mr. DILLON. At this stage in our investigations, there are advantages and disadvantages to each of the media. That is the reason why we have to carry forward the site characterization program that we have described to begin to sharpen and focus so that we can more carefully weigh and trade off those relative advantages and disadvantages for each of the media.

As to the one thing that I think you are concerned about, from the point of view of the media, from the point of view of the environmental location, there is no clear front runner. The die hasn't been cast. We really need this period that we are going to be going through over the next few years to develop the technical information to allow us to make that decision.

My own personal belief, Mr. Marriott, is that all three sites will be fully acceptable for a repository. What we need to weigh is which is the one that will allow us to reach our objectives with the least risk.

Mr. MARRIOTT. Thank you, Mr. Chairman.

Mr. Bereuter?

Mr. BEREUTER. Thank you, Mr. Chairman.

I would first ask the gentleman from Utah if he had a chance to raise questions about delays in hydrologic studies?

Mr. MARRIOTT. No; we have not.

Mr. BEREUTER. I would like to say, Dr. Dillon, that one of the principal continuing problem areas seems to be the delays and tardiness in the hydrologic studies, as compared with the geologic and geochemical. Why have these delays occurred if, in fact, there are delays?

Mr. DILLON. I am going to have to ask Dr. Coffman to answer that, because I was not aware that there was a substantial pattern of delays of hydrologic studies relative to the geological explorations.

Mr. COFFMAN. I would be happy to look into that in more detail for the record. My understanding is that we do have a rather balanced program, looking at the hydrology as well as the geology. At the Hanford site in particular a major portion of the program is aimed at the hydrology where you have aquifers. Likewise, at the Nevada test site, the use of an unsaturated medium as a repository horizon requires you to pay rather careful attention to the hydrology. On the other hand, modeling of hydrology is an art moving toward a science, and we have a way to go there.

I have not heard in my 5 months of involvement in the program that we were slipping or backing off of that.

Mr. BEREUTER. As I have indicated to you, I have contrary information that there are delays in hydrologic studies, and I would ap-

preciate having you investigate whether in fact that is a reasonable assessment. If it is, in your judgment, or we would make that judgment from what you reported, I would like your ideas as to what we can do to expedite work in this area, and we will coordinate these activities.

[EDITOR'S NOTE.—In response to Mr. Bereuter's request, the Department subsequently submitted the following information:]

HYDROLOGIC STUDIES

In its site exploration activities, the Department uses a screening process that begins with regions and large areas and narrows to more specific or focused locations and sites. This characterization includes geologic, hydrologic, environmental and other relevant studies. For each candidate region, we first select from available resources the data that can help determine the more specific locations that are favorable for further study. For example, much information is available on stratigraphy and rock properties that can help reduce our geographic investigations to manageable proportions. In the case of deep hydrology, however, there is limited published information since it is of little or no interest to oil drillers and, being saline, it is also not of interest to users of fresh water.

In some instances, regional features are so uniform that the Department can selectively defer and reduce certain expensive field measurements that are required to determine the specific areas most favorable for further investigation. The depths and sizes necessary for hydrology boreholes incur considerable expense and thus we must carefully consider when such research will be of most value. The Department does not believe there has been either a lack or a delay of hydrologic research; rather it has been conducted extensively where and when it has been most cost-effective for focusing on specific sites in each region.

Mr. BEREUTER. I would like to bring up a broader subject. I would say that, first of all, I have a sense of frustration that the previous Congress, the 96th Congress, was not able to report out a comprehensive or even reasonably comprehensive high-level nuclear waste management bill. I think the House Commerce Committee figured in that problem certainly, and that jurisdictional jealousies figured into it. This year, we seem to have what are apparently interminable delays on the part of the subcommittee chaired by the gentleman from New York, Mr. Ottinger, on reporting out a comprehensive high-level nuclear waste management bill. Time is slipping by again. We have very few weeks left in the 97th Congress.

I would like to ask what the Department of Energy or the administration has said publicly, or would like to say publicly, about the need for a high-level nuclear waste management bill being enacted by the 97th Congress.

Mr. DILLON. The Department would place either first or second priority, certainly an enormously high priority, on successfully getting the high-level nuclear waste management bill through the Congress this year. The Secretary has testified to that effect. It has been the subject of an enormous effort by the Secretary, the Assistant Secretary, and a very large number of DOE staff members. From the Department's perspective, it has an enormously high priority.

I am pleased to say that I think it is a very high priority of the President's also. In his message to the Congress urging support for high-level waste legislation, the President has taken the position that we will set aside the differences and maybe some of the details of various provisions of the bill in order to see a comprehensive piece of waste legislation move through the Congress this year. So it is a very high priority.

BEST DOCUMENT AVAILABLE

Mr. BEREUTER. Reiterating that position, I would say that, by its actions, this committee and the previous Congress and this Congress indicates that it feels it is a very high priority item.

I would be pleased to yield to the chairman.

The CHAIRMAN. One of the reasons I was a little late coming back is that I talked to Mr. Ottinger and he told me that he believed that they would report it out of his Energy Subcommittee today. That is good news, but my goal had been to get it out of the Commerce Committee before the Easter recess, and then the Memorial Day recess. I was sure we were going to get it out of Commerce before the July 4th recess, out of full committee, but it looks like it will go into July now in that stage, which means that we are into July or August with the need for a conference and the Rules Committee and floor action. The window is closing on us right now. Even if we had the best cooperation, it will be a close call.

So we would appreciate the administration keeping everybody's feet to the fire in giving us strong support and scheduling. We are reaching a stage in the congressional cycle where he who says no is greatly advantaged over he who says yes and wants to do something.

Mr. BEREUTER. I thank the chairman for what appears to be encouraging comments from the gentleman from New York. This Member serves notice to anybody who cares to listen that I intend to go to the floor two or three times a week on 1-minute speeches and ask for action on the part of the gentleman from New York and his committee.

I have no further questions or comments, Mr. Chairman.

The CHAIRMAN. Dr. Dillon, when I left, you said you wanted to respond to a couple of things that came up in connection with Chairman Palladino's testimony. Did you do that? Is it in the record?

Mr. DILLON. I put it in the record, sir. It was about your concern about the schedules. I could summarize it in 20 seconds.

The CHAIRMAN. Do it.

Mr. DILLON. The three major bills that have been reported out of committee, the Senate bill and the two House bills, all give a bottom-line construction authorization for a repository that are about 2 or 3 years faster than the reference schedule that is the subject of our DOE planning. We have not changed our official reference schedule, the schedule we talked about last year to the Congress. But we have been looking at all of the schedules that are laid out in the various bills that call for significant acceleration.

It is our belief, based on that quick look, that they are feasible. We think that the kind of schedules set out are very tight, but we are not building in failure for certain. So, we are anxious to see what kind of legislation does move through the Congress. We feel at this stage that we will be able to adjust our program plans to accommodate those.

The CHAIRMAN. Thank you.

I think that concludes this panel. We appreciate it, and we were glad to have you with us. We will be working with you, I am sure.

Mr. DILLON. Thank you very much.

The CHAIRMAN. We will now hear from a panel consisting of Mr. James Devine, Thomas Cotton, Dr. Paul Witherspoon, and Mr. David Watson.

We have another vote scheduled. I am going to run over and get plugged in quickly. When I get back, Mr. Marriott can go over and I will pick up where he leaves off.

Mr. MARRIOTT [presiding]. Mr. Devine, you may proceed.

[Prepared statements of James F. Devine, Thomas A. Cotton, Paul Witherspoon, and David Watson may be found in the appendix.]

PANEL CONSISTING OF JAMES F. DEVINE, ASSISTANT DIRECTOR FOR ENGINEERING GEOLOGY, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR; THOMAS A. COTTON, SENIOR ANALYST, SCIENCE INFORMATION AND NATURAL RESOURCES DIVISION, OFFICE OF TECHNOLOGY ASSESSMENT; PAUL WITHERSPOON, DIRECTOR, EARTH SCIENCES, LAWRENCE BERKELEY LABORATORY; AND DAVID WATSON, MANAGER, MINING AND GEOLOGY DEPARTMENT, KAISER ENGINEERING, INC.

Mr. DEVINE. Mr. Chairman, I can read my prepared statement in full, or provide a summary if you would prefer. I will leave that to you, sir.

Mr. MARRIOTT. Mr. Devine, we are always happy to have summaries and then get into the questions and answers, but it is up to you. If you would like to summarize, your entire statement will be made a part of the record.

Mr. DEVINE. Thank you, sir.

I will start out by thanking you for the opportunity to make these comments today. I do have technical assistants to answer questions you may have, in the form of Dr. Roseboom and Dr. Robertson from the Survey. We also are very appreciative of the attention by this group, this subcommittee, on this subject.

The USGS has been assisting the Department of Energy in various earth science related portions of the waste program. Establishment of a mined geologic repository for high-level radioactive waste involves major geologic and hydrologic questions and forces us to consider a 10,000-year time span for the first time.

We have been conducting specific geologic and hydrologic investigations at various locations, including the salt dome regions of Louisiana, Mississippi, Paradox Basin, Utah, Hanford, and Nevada test sites. We also do research aimed at techniques for investigations. In that regard, we have been at various other sites, such as WIPP in New Mexico. We also have served from time to time as advisers to NRC on various matters in this area.

In our invitation to appear here today, the committee asked for us to address three specific regions. I would like to summarize our comments on those.

As I indicated, we are familiar with the activities involved in all the current sites being investigated, with the exception of the Palo Duro Basin of Texas. So I won't offer any comments concerning that site today.

There is one fundamental issue that seems to be apparent at all sites, and that is a quantitative understanding of the subsurface

hydrologic system. In the Nevada test site, a major unresolved issue is whether the transport time for radionuclides will be sufficiently long to meet NRC and EPA requirements. The transport path in three dimensions and the rate of movement are poorly understood today. Second, placement of a repository above the water table is a relatively new concept and has not been studied in any great depth at this stage.

There also is an issue remaining concerning the state of stress in the material being mined, and whether such stress will allow mining to proceed. The final issue concerning Nevada is the complexity and variability of the physical properties and the mineralogy of the tuffs which set limits on the temperatures to which tuff can be subjected and makes it difficult to predict the overall behavior of a repository.

At the Hanford site, known as BWIP, several geologic and hydrologic issues are in need of resolution. The most important one relates to an inadequate understanding of the hydrologic system and the regional and local geologic stress conditions.

Again, the path and travel time of nuclides in ground water are at this time not adequately known. The state of stress of the rocks in the proposed area need to be determined more fully.

In the Paradox Basin, Utah, the major unresolved issue is the hydrology and the transport time of the radionuclides. There is a second issue of the effects of a small amount of water in the salt beds and its impact. It is understood that such water would migrate toward the source of heat, such as the waste canisters. This needs to be evaluated more fully.

A third issue is the rate of which methane would move into the repository from the interbeds of black shale in the salt formation. This is primarily a safety concern during the construction and operation of such a repository. It is not a long-term risk.

The gulf coast salt domes in Louisiana and Mississippi have some geologic and hydrologic issues that are remaining. The structure of each candidate salt dome must be clearly defined. They vary in composition and structure, and each one would need to be understood if it were a candidate site.

The caprock above a salt dome represents a rather unique problem and it needs to be evaluated, as it provides a potential avenue for movement of waste-bearing fluids.

Finally, the existing stress fields and the effects of the superimposed compressive thermal stresses produced by the wastes must be evaluated in these salt domes.

The second area that you asked us to comment on has to do with our assessment of DOE's program for resolutions of issues remaining. I would like to state that we feel we have a close and formal cooperative program with DOE. We are confident that they are aware of the major identified, unresolved issues at each of the sites. However, our past experience taught us to expect surprises, and even temporary failures, when entering into extensive geologic and hydrologic investigations.

I would point out that neither a repository or a test evaluation facility has ever been built, characterized or licensed as of today. This is a learn-as-we-go procedure.

Mr. MARRIOTT. Mr. Devine, I think what we will do, with your permission, is recess for 5 minutes. Mr. Udall will be back before that and we can continue. We will go ahead and catch this vote, if it is OK, and be back in 5 minutes.

The CHAIRMAN. We will continue. Mr. Devine, you may finish your statement.

Mr. DEVINE. From a technical standpoint, we believe that to obtain the necessary Earth science information, it requires about 3 years after the exploratory shaft and associated underground test workings are completed. That is assuming all the tests that we take work successfully. DOE has what appears to be an adequate program to answer the questions, given adequate time and resources.

The third area we were asked to comment on was our assessment of the readiness of the Nuclear Regulatory Commission. I would like to say that the USGS is really not in a position to make a formal assessment on NRC's readiness. However, we are aware that the staff members of NRC indeed are aware of the unresolved issues and are making an impressive effort to collect and evaluate the necessary information.

We would agree with their testimony that it is necessary that they have early access to technical data and in the method in which the data are collected. They should otherwise be kept well informed on the plans and progress of the site characterization programs.

In summary of our answers to the questions you asked of us, sir, are as follows:

Although several major technical issues remain unresolved at all the sites currently being evaluated, there is no reason to think that the issues cannot be resolved with the DOE planned program, given adequate time and resources. Both DOE and NRC appear to be aware of the issues and the types of studies necessary to resolve them. The Geological Survey remains ready to offer what technical assistance we can to both agencies.

That concludes my comments.

The CHAIRMAN. Thank you, Mr. Devine. We will save questions until the end of the four panelists.

We will now hear from Dr. Thomas Cotton, Senior Analyst, Science Information and Natural Resources Division, Office of Technology Assessment.

Dr. COTTON. Mr. Chairman, for the record, I am the Director of the Office of Technology Assessment's study of commercial high-level radioactive waste management. I thank you for the opportunity to appear before the committee today to discuss some of the results of our study and to answer any questions you might have.

Our study focused on the relationships on all of the technical and institutional elements of a high-level waste management system, rather than the technical details of individual elements such as the specific tests involved in evaluating repository sites. Nonetheless, part of the analysis done during the course of our study did address aspects of the site evaluation process and suggests some conclusions that may be relevant to the questions you are considering today. The results of that analysis are described in detail in an article which I have included as an appendix to our testimony.

With your permission, I would like to submit my written testimony and an extended background statement for the record, and confine my remarks today to a brief discussion of the approach we took in that analysis and some of its main implications.

The CHAIRMAN. That will be done. Thank you.

Dr. COTTON. This analysis that we did was addressed to one specific question: What can be done to give high confidence that a licensed and operating geologic repository will be available when you want it? This question immediately raises a second one, which is: How many potential sites need to be evaluated to be sure of finding one or more that is suitable for a repository? If the answer to that latter question is that many sites have to be examined, then one either has to allow time to examine one after another until a suitable one is found, or—if time is limited—one must be willing to examine a number in parallel so that backups are available to minimize the loss of time if one or more are rejected.

The process of evaluating repository sites involve several successive phases of investigation, including the initial screening to identify potentially suitable areas, surface testing, in site testing at repository depth using a shaft—generally referred to as characterization—construction, operation, and closure. At each successive phase of site investigation, more complete information about the viability of a proposed repository can be expected. In some instances, this information will be used to reject a particular site from further consideration; while in others, the data will result in greater confidence in the suitability of the site.

Since these phases become increasingly expensive, particularly after excavation has begun, it becomes important to know how far along this investigation process one must go to be highly confident that a site would be suitable for a repository. Discussions with a small range of experts during the course of our study revealed the lack of consensus on this question. While some felt that a site that appears suitable after in situ characterization will have a very high probability of making it all the way through the licensing process, others believe that there may remain a substantial chance, perhaps 30 to 40 percent, that an apparently suitable site could be rejected at some point after submission of an application for a construction permit.

Because there is of yet no experience at actually characterizing, licensing, and constructing repositories, and since the final criteria and standards a repository must meet have not been adopted yet, this lack of consensus cannot be resolved at present and is simply a fact of life that must be considered in determining the appropriate approach for investigating sites for repository development.

If the more optimistic view is correct, there is little risk in quickly narrowing attention to several sites for in situ characterization. If the more conservative view proves to be correct, then there may be as much as a 30 percent chance that three sites carried into characterization might fail to produce a single operating repository. In this case, the additional cost of characterizing more sites might be good insurance against that risk.

H.R. 3809 and the other bills now under consideration by Congress focus on the process of selecting a single site from the set of candidates now under consideration and carrying that site through

the licensing process. Thus, the important question is how to maximize the probability of selecting a suitable site from among a more or less fixed set of alternatives in time to meet a fixed schedule.

In contrast, our analysis posed the question of how large a set of alternatives must be examined in order to be sure that at least one is successful, which is a somewhat different question. Nonetheless, our analysis does suggest some observations that are relevant to the question posed by H.R. 3809. Since the number of sites now under consideration is fixed, the overall likelihood that one or more that are suitable for repository development can be found among them is also fixed. If there is a licensable repository there, you can find it sooner or later by trying to license them one at a time. This is probably the least expensive path, at least in terms of the front-end costs, but it involves the risks of delays and the associated financial and political costs if you do not pick a good site the first time.

Since the 1998 target date for an operating repository that is contained in H.R. 3809 does not appear to allow time to try again if the first site submitted for licensing is rejected at some point, it becomes particularly important to insure that the best site is selected the first time.

While our analysis showed a range of disagreement about how sure you can be that a site that looks good after characterization will ultimately be licensed for operation, we did find a general agreement that the in situ characterization phase itself is one of the most important stages in determining the suitability of a site for development. Even if there were no NRC requirement for in situ testing before construction, DOE would certainly conduct such tests on its own before incurring the large costs of building a repository.

A particularly important question, therefore, is how much time will be required in this phase to determine the information needed to justify the next step, which is submission of an application for a construction permit? If inadequate time is allowed at this stage before a site is selected for licensing, there is a chance that the site that would have the best chance of being developed into a repository in the long run could be passed over in favor of another less well suited site whose flaws might not become apparent until later in the characterization process after a choice had already been made.

The estimates developed for our study through discussions with DOE contractors indicated that from 4 to 6 years might be needed for in situ characterization, including the time required to sink a shaft to repository depth before tests have begun. Mr. Devine has just indicated that the Geological Survey believes that about 3 years of tests at depth, once the shaft has been sunk, may be needed to provide enough information to proceed to construction, assuming that everything goes well. We have not seen studies that suggest that much less time at depth would be required, and the uncertainties about the time needed tend to go in the direction of how much longer it might take.

The current DOE reference schedule may involve some risk of premature decisions about which site to submit for licensing since it allows only about 2 years for conducting tests at depth during

site characterization once a shaft has been sunk and the necessary facilities prepared. Of course, data from 3 years of that depth testing or more would be available before a final NRC licensing decision, even under the current DOE schedule, assuming that the testing is continued during the licensing process. However, selection of the site to submit for licensing on the basis of only 2 years of data could lead to discovery of information that would disqualify the site after it had been approved by the President and the Congress and submitted to NRC, rather than before. The consequences of a rejection could be far greater in that case than if the site had simply been disqualified during characterization and another chosen for licensing.

The schedule in H.R. 3809 accelerates the date for submission of a license application by about 1 year over the DOE schedule. That allows about 3½ years from beginning a shaft for characterization to recommending a site for licensing. This could lead to further reduction in the time available for in situ testing before a site is selected for licensing, thus increasing the risk that information that might disqualify a site would be found during licensing rather than before.

Since we have no experience at actually characterizing the potential repository site and reviewing it in the licensing process, a process which, in itself has not been defined in detail, we cannot say precisely how much a particular reduction of the time allowed for in situ testing would increase the chance that a site other than the one with the best chance for licensing would be chosen by DOE and submitted to NRC. Indeed, there appear to be enough unresolved questions about precisely what will have to be done during in situ characterization that we cannot be sure that the chance of a mistake would be eliminated even if 3 or 4 years were allowed.

However, the potential problem could be reduced if DOE were simply to submit the two best sites for licensing simultaneously. In this way, even if continued testing during a licensing process reveals information that leads to the disqualification of one of them, the chances that this would occur with both should be substantially lower. The additional cost of submitting another site for licensing, if one were available, would surely be trivial compared to the cost that would already have been spent to characterize it in the first place, and the potential benefit could be avoidance of up to an 8-year delay that could result if the licensing of the second candidate site was not initiated until and if the first was rejected.

Mr. Chairman, that concludes my oral remarks today. I will be glad to respond to any questions you might have.

The CHAIRMAN. Thank you.

We will now hear from Dr. Paul Witherspoon.

Mr. WITHERSPOON. Mr. Chairman and members of the committee, I appreciate this opportunity to be able to testify on this important national matter. As you know, I appeared before this committee last July on certain aspects of this question, and I appreciate this return invitation to provide you with my views on necessary and appropriate testing for the characterization and confirmation geological sites for high-level waste disposal.

Geological engineers are being called upon to resolve a number of technical issues central to the successful development of mined

repositories. While I believe in the eventual success of the endeavor, I do not believe we are presently prepared to resolve all of the technical issues with professional certainty. Furthermore, I am concerned that the present program plans do not provide the time and resources needed to prepare us technologically.

Mr. Devine has commented on some of these things in earlier testimony before some of the Senate committees, and has discussed some of the problems that could occur from proceeding unnecessarily fast. My complete statement has a quote from his testimony, and I would concur with the remarks he made at that time.

I want to turn, in attempting to address this question on the testing, to the two key phases: the repository site characterization and repository site confirmation.

If I may, Mr. Chairman, I would like to use a little diagram here that would illustrate what I am talking about and the timeframe that I have in mind for these two phases.

The CHAIRMAN. Is it common for old professors to explain things best when they can get to a blackboard or a diagram?

Mr. WITHERSPOON. You have to be standing. You can't think too well when you are sitting down.

[Chart shown.]

Mr. WITHERSPOON. I have illustrated here site characterization, which I mean shaft sinking plus testing. Then there is a period of licensing. In other words, a license application would presumably be submitted at the end of site characterization, and then the licensing process would carry through to a decision point, after which construction would begin. That construction period is really part of the site confirmation. As your H.R. 3809 indicates, site confirmation can carry on into the operational phases for some period of time.

With regard to site characterization, what are some of the crucial decisions that have to be made? I have itemized these in this prepared statement which you have before you, and I will simply try to summarize these very briefly.

The lateral continuity of the candidate horizon is a very important problem. We envision a repository 2 miles by 2 miles—in other words, 4 square miles. You want to be sure that there is a continuity of that candidate horizon, at least over the repository and on into the surrounding regions as well, then all rock types have discontinuities. The nature, the orientation, the extent of these has simply got to be determined.

The in situ state of stress derives from the fact that the repository, which might be illustrated by that sheet of paper, is at some depth below the surface, and the weight of all of the rocks above create a state of stress on those rocks. One must know what that is.

Obviously, the permeability of the rocks surrounding the repository will control the migration of the ground water with radioactivity in it at some future date. What is the permeability of the rocks surrounding that repository?

The effective porosity is just another measure of the rock properties that control velocity of movement.

Finally, one of the tough problems is what size sample of the rock mass should you study in the underground in order to have a statistically significant sample.

All of those factors, as far as I am concerned, must be studied in the underground. You can get at certain aspects of it from surface drilling, but ultimately you need to get underground. It appears that two shafts will be required to get into this problem, and I have simply estimated about 3 years might be required for that operation. The testing to elucidate these factors that I have described would be another 3-year period.

So, I see site characterization, as I define it, as about 6 years, which seems to be in accord with what some of the other people have been discussing this morning. But it is a little bit longer than some of the time periods envisioned in various House and Senate bills. I don't believe this is a serious difference.

That gets us up to the point where one can submit a license application. But the important point to keep in mind is that this testing simply has to be done underground in order to get the kind of data that you need to decide upon the submission of a license application.

The development of this first high-level waste repository in the United States is literally at the forefront of this developing technology, especially as regards the assurances mandated by the licensing process. I contend that the process will be smooth, and the program's success improved through the development and proof testing of these new engineering methodologies that are going to be required at the potential sites. There is the problem, then, of developing some technology to carry out the underground measurements for the data that I have described.

The site confirmation phase, which would involve construction and could carry on over into the operating period, involves a more difficult problem, and that is the one that derives from the fact that there will be a significant amount of heat released by the waste, and that heat will raise the temperature of this very large rock mass and creates a thermal pulse from the emplaced waste. I discussed it to some extent in my July testimony. This thermal pulse will alter the characteristics of the rock mass.

It may also have a significant thermal convection, because, as you can envision, the water within this repository later that is rising in temperature, its density becomes less than that of surrounding cold water and the water wants to rise vertically upward. It is a natural convection.

What are the factors that control that? In my view, they could only be studied in the underground with an appropriate scaled test that can get at the factors that control this. We have lots of theoretical studies about this kind of behavior. The difficulty is that this work has not been validated by being able to utilize site-specific data from the underground and, therefore, the studies can't be relied upon at this point because there is no way of being able to show how well they can be verified.

Both DOE and NRC are currently developing mathematical models that will be used to make long-term predictions of repository integrity and isolation capabilities. Such predictive work must be able to handle the coupling of this thermo-mechanical-hydraulic effect, but the engineering tests and the experiments to make these models useful in the real world and to allow their application to specific situations do not now exist.

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The tests required to determine repository response to this thermal load cannot be done quickly. It simply takes time for a large rock mass to heat up so you can observe the effects and study what happens, not only during the increasing temperatures, but during the decreasing temperatures—and certainly not within the timeframe of the construction licensing schedules.

However, it seems to me that simply by changing the schedule somewhat, these thermal tests could start back in the site characterization period and could continue right on through the licensing and on into the construction period. I assume that the construction may take something like 6 years so that, combined with the time of the licensing, as well as this testing period in the site characterization, provides a significant period of time wherein these thermal effects could be investigated at any candidate site.

The question of the appropriate methodology to carry out the test is a concern that I have. Our work shows that to develop and verify the needed methodologies for this thermal problem will probably require something like 5 years. To avoid delays, the work to develop the methodologies to carry out these tests, in my view, should start immediately and be vigorously pursued. Much of the effort must occur underground at a typical repository depth. But it would appear that it can't use repository sites where candidate formations are being studied because of scheduling problems. It is my view, therefore, that one should pursue this question of developing the methodology in a generic sense, removed from the site-specific issues and schedules.

This tends to bring up the question of the test and evaluation facility that was discussed somewhat earlier this morning. This TEF concept has been most completely developed in H.R. 5016, and has three principal components in support of repository site development: First, provide an unlicensed R. & D. facility for the development and verification of technologies, including testing methods and instrumentation; second, provide a mock repository setting for testing and training in logistical areas such as waste handling and emplacement; and third, provide space and facilities to investigate any site-specific issues that may develop after construction license application.

Obviously, the last component on site-specific issues would have to occur at some selected site where the activities could be pursued in the candidate horizon.

I fear, however, that with regard to the first two features, the anticipated contributions will be less than optimal if they are located at the candidate site due to the attention that management must focus on site development, and the necessity of maintaining development schedules.

I would recommend that these two components be separated and neither of them should be carried out at a candidate site. The mock repository facility should be located at one of the existing Federal facilities, such as the Nevada site or the Hanford Reservation, where facilities for handling radioactive waste already exist.

The R. & D. component should be organized as a generic test facility. I will speak about this a little more in detail. I believe that separating the three components of the TEF concept in this

manner is cost effective, consistent with the overall program schedule, and a prudent step to take at this point.

With regard to this generic test facility, it seems to me it does not need to be licensed, there is no need at all for any radioactive waste to be used in such a facility, and it could quickly be placed in operation because it can be located as an extension of an existing underground mine. It would be essentially the same as the work we did at Stripa in Sweden.

The facility should be devoted to the R. & D. efforts needed to provide the technologies required for reliable site characterization and site confirmation tests. I am not sure that this was fully understood by the gentleman from NRC when you asked him a question about this proposed generic test facility. I don't believe they realize that what I was saying was that the methods that could be developed in a generic test facility would then lead to their application at candidate sites. I feel the application would, therefore, be more effective than is now possible.

In the early stages, this generic test facility can focus on the methodologies that would lead to the testing for site characterization. In the later stages of this work, one would be developing the methodologies that could test this more complicated problem of the thermal response that lasts over a significant period of time.

Startup of this existing underground mine in, say, calendar year 1983, could provide appropriate lead time to prepare characterization methodologies for application at the first sites now under development. That would mean that one could start the generic test facility operations way back somewhere in approximately here. In about 1 year, one could begin to get the methodologies underway, and the results of that work, it seems to me, could then be factored into the candidate site selection process, the site characterization followed by site confirmation, in a very efficient manner.

To summarize, Mr. Chairman, from the standpoint of the testing requirements for the characterization and confirmation phase that you asked me to address, I believe we can adequately characterize geological formations to meet construction license criteria, and that we will be able to credibly predict a repository's performance for operational licensing. However, to do so based on present geotechnical knowledge, using today's technologies and according to the proposed schedules, in my view, is not at all likely.

I do not recommend delaying the program. It should be paced as fast as the administrative and engineering processes will allow. I do, however, strongly recommend an equally forceful parallel effort to develop the techniques and engineering knowhow that I believe are vital to the success of this program. Central to such a supporting R. & D. program is a generic at-depth test facility as I outlined today.

That completes my statement, Mr. Chairman.

The CHAIRMAN. Thank you for your excellent testimony. If you will stand by, we may have questions of you.

We will now hear from Mr. David Watson, Kaiser Engineers, Inc.

Mr. WATSON. Thank you, Mr. Chairman.

By way of introduction, I am David Watson, manager of the mining and geology department for Kaiser Engineers in Oakland, Calif. I have been working on the mining portions of mine geologic

repositories for nuclear waste for about the last 5 years, including the conceptual design for a bedded salt facility. I am presently working on the basalt waste isolation process at Hanford, Wash., under contract with the Department of Energy.

With your permission, Mr. Chairman, I will summarize my written statement, in the interest of time.

The CHAIRMAN. That will be fine.

Mr. WATSON. Thank you, sir.

The testimony which I am providing today is in answer to a request by this subcommittee to provide information regarding underground exploration and construction activities at possible repository sites. The specific information which you requested was a description of mining technology appropriate for mine geologic repositories, a description of the appropriate exploratory work required to characterize the geologic formation for the repositories, an estimate of the amount of time required to complete distinct site characterization and development activities, and an estimate of the cost of mining engineering activities.

I have provided you in my written testimony with a prospective drawing of the proposed conceptual design for a repository at Hanford, Wash. From this drawing, it can be seen that the planned repository consists of surface facilities for receiving and handling of waste, shafts to transport personnel, supplies, ventilating air and waste from the surface to the subsurface facilities, a central shaft pillar, and a system of entries and storage rooms.

While the planned repository is unique in its function, it does have many similarities to existing underground mines. Construction of such a repository can be generally accomplished using existing technology familiar to the U.S. mining industry. There are, however, certain details of the construction which could benefit from some additional research and development.

The shafts presently contemplated, for example, at Hanford vary in size from 6 feet in diameter to 16 feet in diameter for an operating repository. Shafts of this size have been sunk in mineral producing areas throughout the world. And the depths that are involved of 2,000 to 4,000 feet for repositories in the various rock types are certainly within proven technology, as is the equipment for equipping them with modern hoisting installations.

There are, however, certain shaft design and construction considerations which are peculiar to a repository, and which do require further analysis. One of these considerations is the amount of disturbance experienced by the rock around the shaft opening as a result of excavation. While this disturbance is controllable for mining purposes, it might become a pathway for possible radionuclide migration to the biosphere in the event of an accidental release underground. The extent of this disturbance in the various rock types is not adequately known at this time, nor is the difference in the amount of disturbance caused by different excavation methods known except in a qualitative sense. It is likely that disturbance is less using boring techniques than drilling and blasting, although controlled blasting techniques limit this disturbance in the latter case.

A second consideration is the method of final sealing of the shafts when the repository is decommissioned. While this decom-

missioning is far into the future, about 80 years after repository construction begins, the impact of the seals upon the shafts must be understood before final design of the repository. Otherwise, the design and construction of the shafts could be done in such a manner as to preclude the installation of a suitable seal.

With regard to horizontal development, the horizontal workings of a repository will consist of facilities near the shafts, such as shops, warehouses, offices, haulage and ventilation entries to and from the storage area, storage rooms and storage positions within the rooms.

The sizes of these underground openings presently planned for the basalt repository program vary from 10 feet by 10 feet wide for exploration drifts, to 10 feet high by 20 feet wide for storage rooms. Other repository designs, in salt, for example, have considered storage rooms 20 feet high by 20 feet wide. Underground openings of these sizes have been constructed as part of mining or hydroelectric projects and are feasible for a repository.

While proven underground mine development and tunnel construction methods are available for the development of a repository, there are several technical considerations which merit additional study and testing. The use of long, small diameter, horizontal core holes could be very useful to explore an area proposed for a repository. There have been some examples of holes drilled up to 5,000 feet, but the technology is still in need of further development.

Second, because of the present plans for a repository contemplate simultaneous development of storage space and waste handling, it will be necessary to continually probe ahead of an advancing excavation to avoid geologic hazards which are not otherwise discovered. This safety precaution is normally undertaken in mines when required by drilling a pilot hole ahead of the face. Work is being done now to perfect geophysical sensing methods which could be used to improve the reliability of such probe holes in detecting hazards.

Finally, the two most common plans for the storage positions of the waste are vertical holes drilled in the floor of the storage room and horizontal holes drilled into the walls of the room. Horizontal storage offers economic advantages in terms of total excavation, but testing is needed to verify the feasibility of boring large diameter holes, say, 3 to 4 feet in diameter, to accommodate the waste package over horizontal distances approaching 200 feet.

With regard to ventilation, nuclear waste stored in underground rooms will release considerable heat over the life of a repository. Because of the requirement for potential retrieval of the waste, the repository must possess the capacity to ventilate and cool storage rooms on an individual basis. In addition, the normal ventilation and air conditioning requirements of an operating underground facility must be met.

The ventilation and air conditioning system for a repository will be extensive, but similar systems are found in other large underground mines. The repository system, however, will need the capability to filter exhaust air in the event of an accidental discharge of radioactivity. This type of filtering equipment is available.

With regard to your question on exploration, geologic repositories that are to be constructed in a geologic environment have a number of unknowns associated with them. The experience of the mining industry that has traditionally dealt with underground structures and their problems should be examined and utilized where applicable in the repository program. While the application of the concept of "proving an ore body" for a nuclear waste repository differs in details from that of a conventional mine, the basic concept is valid—that is that sufficient detailed examination of the underground area in which the repository is planned to be built should be accomplished to prove that it has the necessary integrity before a final decision is made for the full capital expenditure program.

While repository programs can draw from mining industry practices and major elements of mining exploration programs, differences between repository and mine development programs must be recognized. For a mine, the characteristics of the ore body itself and its immediate surroundings are of primary interest; however, for a repository the exploratory program must cover not only the waste storage area itself, but also the surrounding region to confirm that the waste storage area will have the required degree of isolation and that potential changes in the regional geologic conditions will not impair the overall integrity of the repository system.

As indicated previously, there are also major differences in the extent of surface boring that is possible—exploration mapping for mines can involve bore holes from the surface on 200-foot by 400-foot centers, whereas this number of drill holes is not permissible for a potential repository site. Thus, this element of a repository exploration program must be accomplished underground using extensive tunneling and horizontal bore holes at the storage horizon.

Plans for underground exploration programs have been developed as a part of the conceptual design of two repositories, for the bedded salt repository, the national waste terminal storage repository #2, and for the nuclear waste repository in basalt at Hanford. I will refer for the sake of brevity to the program at Hanford.

The subsurface facilities layout developed during the conceptual design of the repository at Hanford encompasses a 1,900-acre area approximately 2 miles long by 1½ miles wide, in a basalt flow of approximately 3,700 feet below the Earth's surface.

The exploration program planned in this conceptual design provides for: an exploratory shaft to the reference repository horizon for site characterization; followed by tunnels and horizontal drill holes for repository design confirmation in and adjacent to the shaft pillar; and subsequently, exploratory mapping of the storage horizon over an area equivalent to that area needed for at least the first 5 years of waste receipts. This program would involve a second shaft, 4 miles of exploration drifts, and directionally controlled horizontal bore holes at about 900-foot intervals from these drifts.

You have been provided in the written testimony with a drawing prepared as part of the conceptual design of this repository which indicates the exploratory program.

The exploratory shaft—it is in final design at the present time—encompasses a nearby bore hole which has been drilled through the next competent flow below the reference horizon prior to the

start of shaft construction in order to obtain site-specific information for the design.

In addition, the exploratory shaft will be sunk at the reference repository location to demonstrate construction feasibility, and to provide access to the reference repository horizon for in situ characterization. The exploratory shaft will be 110 inches in diameter, drilled to about 3,800 feet, and lined with a 6-foot inside diameter steel liner.

Tests will be performed through portholes from inside the shaft and subsequent shaft breakout into the reference repository horizon will verify the performance of the grout seal and construction-affected zone to safely isolate the reference horizon from the Hanford groundwater system.

At the conclusion of the initial tests from the exploratory shaft, a decision to sink a second shaft and carry out an extended underground exploration program will be in order.

With regard to your question on safety, the exploratory shaft is being designed and constructed in accordance with 30 CFR 57, "Health and Safety Standards—Metal and Nonmetallic Underground Mines," and other applicable safety standards. The exploratory shaft is considered part of an exploratory program and is not classified as development. All ES activity will be monitored by DOE's program manager, Rockwell Hanford Operations, and integrated into the general Hanford site emergency plans.

With regard to your question on the schedule——

The CHAIRMAN. We are about to get into some time problems here. We have the whole statement for the record. Have you made most of your major points?

Mr. WATSON. I have left only the schedule.

The CHAIRMAN. All right.

Mr. WATSON. The time required to adequately explore a site and develop a repository for initial waste storage will necessarily depend upon location, rock type, and depth below the surface. Using the basalt site as an example, a possible schedule would be about 6 to 8 years for the exploratory work, and approximately 8 to 10 years for the repository development work.

The exploratory work that I am referring to is defined as work completed before the start of field construction. That includes the repository underground development and surface construction.

The rest of my testimony is concerned with the cost of the mining engineering effort. I think that is self-explanatory. That concludes my testimony.

The CHAIRMAN. It was very helpful.

Dr. Witherspoon, you obviously have great scientific knowledge and are a highly regarded person in this important field that we are concerned with. You leave me with kind of a pessimistic feeling here. I first got into this back in the 1960's, and it became a cliche in the 1960's and 1970's to say that there was no engineering or scientific problem with nuclear waste, it was simply a political problem.

It seems today, in light of your testimony and some of the other things we have heard, that we may have a hell of a lot of engineering and scientific problems that aren't resolved yet from the standpoint of coming up with a program.

The other thing that discourages me a little bit—and I am not blaming you for this. You undoubtedly have a great scientific background in which to make these estimates. But you seem to be saying that we are far too optimistic, that my bill which we have worked out over these last few years which says that we can have a licensed repository in the early 1990's, that this is not realistic and that, if we do it the way we really want to do it and make sure we have done it right, we are talking about not licensing a repository until the late 1990's or even beyond.

Have I correctly characterized your testimony?

Mr. WITHERSPOON. If I can refer back to the drawing I had, the site characterization period there that I described was about 6 years. The licensing, I will assume, is about 3 years. The construction period would be about 6 more. So there is 15 years. If you start in 1983, plus 15, it is 1998. It is approximately mid-1990's when you would be through the process that I have in mind.

I don't share your pessimism, with all due respect, sir. I believe that the generic test facility I described can be started immediately to get at the problems that I tried to describe. It is not a hopeless situation, but it is one that requires appropriate underground testing in a new methodology. I am not really saying that the proposed schedules are that far out of line with my thinking.

The CHAIRMAN. All right.

Mr. BEREUTER. Would the chairman yield on that point?

The CHAIRMAN. Sure. I have finished. Go ahead on that point.

Mr. BEREUTER. On that point, it seems to offer some support for the wisdom of also moving ahead with monitorable retrievable storage while we are engaged in a difficult quest for answers to deep geologic storage.

The CHAIRMAN. Mr. Marriott?

Mr. MARRIOTT. Thank you, Mr. Chairman.

I have just one question of Dr. Devine, if I may, on the water issue. Your testimony indicates a need to achieve a more quantitative understanding of subsurface hydrological systems at the Nevada site, the Utah site, and the Hanford site. I am looking particularly at your testimony on page 7, where you discuss in the first paragraph or two the Paradox basin site.

Let me ask you, pertaining to that statement, a couple of questions. Do you agree with comments made earlier in this hearing by the DOE that the hydrological work is moving at a compatible rate with other geoscience analysis?

Mr. DEVINE. Sir, I am not sure I have sufficient information to evaluate the rate of data acquisition in the hydrologic regime compared to geologic. We see the data in sort of isolated segments. It would be very difficult for me to compare one to the other. The qualitative statement about the time required to acquire hydrologic data we can state by itself. But to do a proper evaluation as to whether that schedule is ahead, or on, or behind the rate of geologic information, that is a question I just can't answer directly.

Mr. BEREUTER. Do you anticipate that additional hydrological data might, in fact, eliminate any of these sites now under consideration?

Mr. DEVINE. That is always a possibility, not knowing ahead of time what it is you are going to acquire.

Mr. BEREUTER. But you don't have any information at this point that the hydrological issues are going to put any of the sites out of business?

Mr. DEVINE. No; we do not.

Mr. MARRIOTT. Let me ask you another question. As I read your testimony—and correct me if I am wrong because I have been in and out of this place so many times today, I am not sure exactly where we are—but let us take the Paradox Basin for just a minute. We hear some problems emerging from the task force out there and from other groups that perhaps there are some water problems, that the salt formation and water poses some serious problems. With the Colorado River being not too far away, and with possible underground tributaries, et cetera, there should be some concern about the water issue.

Could you address water and salt and the Colorado River and the potential problems, and let us have any information that might be helpful to this committee?

Mr. DEVINE. I think I could address that only in the generic sense, in that we have maintained the position for quite some time that, to adequately isolate radioactive waste, it would require a multiple barrier concept, both engineering and natural barriers, in unison or in conjunction with each other.

I would have to submit for the record any comments specifically relating to migration of water relative to the Colorado River. I do not have that ready at the moment, but I would be willing to provide that for the record.

Mr. MARRIOTT. OK.

Let me go one step further. Is it possible that the water problems with salt and the proximity of the Colorado River may be a problem?

Mr. DEVINE. Without having the complete set of data, obviously the answer to that question would be yes, it may be a problem. But, on the other side, it may not be.

Mr. MARRIOTT. But at this point, the only thing you can conclude is that you don't have enough information about the water at the Paradox Basin to make any judgment one way or the other?

Mr. DEVINE. At this stage, that is correct.

Mr. MARRIOTT. Thank you, Mr. Chairman.

[EDITOR'S NOTE.—In response to Mr. Marriott's inquiry, the U.S. Geological Survey subsequently submitted the following information:]

QUESTION

Are there problems concerning migration of water from the Gibson Dome area to the Colorado River?

At Gibson Dome, the Paradox salt is immediately overlain and underlain by thick, relatively impervious sediments which appear to effectively isolate the salt from circulating ground water. Two regional aquifer systems are present in the area; an upper regional aquifer which overlies the impervious sediments about 1400 feet above the salt and a lower regional aquifer system which underlies the impervious sediments about 350 feet below the salt. Current information indicates that the two systems are not connected in the Gibson Dome area. Hydraulic head in the upper aquifer is higher than the hydraulic head in the lower aquifer, which means that ground water has the potential to flow vertically downward. Regional movement of water in the upper aquifer is from the upland recharge areas to the Colorado River where it is discharged. Movement of ground water in the lower aquifer

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system is toward the south and southwest and discharge of ground water from this system is not known to occur within the Paradox Basin. A salinity survey of the Colorado River eight to ten miles west of Gibson Dome did not indicate any detectable increase in salinity such as would be expected if the upper aquifer system were dissolving salt from the Paradox formation. The limited available information concerning the hydrology of Gibson Dome area does not indicate that problems exist concerning the potential migration of water from the Gibson Dome area to the Colorado River. However, current hydrologic data are inadequate to provide the degree of understanding of the hydrology required to judge the suitability of the area for a high-level nuclear waste repository. Studies which include drilling and testing will be required to obtain the necessary information.

Mr. CHAIRMAN. Mr. Bereuter.

Mr. BEREUTER. Thank you, Mr. Chairman.

I directed a question earlier to Dr. Dillon of the DOE regarding his knowledge or those people accompanying him about the delays or tardiness of the hydrologic studies compared to the geologic or geochemical studies.

Would any of you gentlemen care to comment on whether or not, in fact, we have some delays with respect to the hydrologic studies?

Mr. WITHERSPOON. Just for clarification, these are delays in hydrologic studies with regard to——

Mr. BEREUTER. I assume, the candidate sites.

Mr. WITHERSPOON. I haven't heard of any evidence that there are delays. I believe that, at each candidate site, they are proceeding to gather data as rapidly as the schedules and resources permit. Until they are able to get underground and do the underground testing that I have described here today, one doesn't get a complete picture. But you do have to go at these things in stages.

Mr. BEREUTER. Sometime in the future, 8, 10, 11, 14 years from now, somebody may look back at this hearing and what was said here. Maybe you could bear that in mind in responding to the next question. I would like to address it to Dr. Witherspoon, and invite any comments from the other gentlemen, if you care to make them.

Isn't it, given current technology, impossible to measure consistency characteristics of natural media?

Mr. WITHERSPOON. Consistency of characterization?

Mr. BEREUTER. The character or the consistency of natural media as compared to man-made media, isn't it practically impossible to measure in natural media? You can take samples, but you cannot for certain say what the character of it is, the consistency of the characteristics, from one portion to another; isn't that the fact?

Mr. WITHERSPOON. I beg to differ with you, sir.

Mr. BEREUTER. Tell me how you would do it.

Mr. WITHERSPOON. How do you do it? If we are talking about permeability, for example, the ability of a rock to conduct fluid, which would be one of the very important features of a waste repository, one can obtain rock samples and those can be studied in a laboratory. That is one approach.

Mr. BEREUTER. How do you determine if there is a cavity or not? How do you determine for certain if there is a cavity or some other geologic formation in part within what you assume to be a consistent characteristic or consistency of that media?

Mr. WITHERSPOON. As Mr. Watson will perhaps pick up here, and I will try to summarize my view of this, one needs to get into the

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underground with a shaft and in these tunnels. It may be of interest for you to know that in the construction of a tunnel between the islands of Japan, Hokkaido and Honshu, bore holes were drilled literally almost up to a mile and a half, small bore holes, in whatever direction the Japanese felt they needed to know what were rock conditions out in front, were there cavities, were there high water pressures.

Mr. BEREUTER. With what frequency?

Mr. WITHERSPOON. They had this continuously.

Mr. BEREUTER. I mean in distance. Do you put them x apart, y apart, z apart? How do you determine without any doubt that you are dealing with a consistent media?

Mr. WITHERSPOON. One can approach that from what is called geostatistics, and you would have a number of horizontal bore holes at the repository horizon sufficient to give you a statistical sample of that horizon.

Mr. BEREUTER. What you are dealing with is a sample.

Mr. WITHERSPOON. That is correct.

Mr. BEREUTER. That is a sophisticated way of saying you are dealing with the sample, you are testing whatever you happen to penetrate with that bore hole.

Mr. WITHERSPOON. That is right.

Mr. BEREUTER. So it is impossible, given current technology, to determine that indeed you are dealing with a consistent media?

Mr. WITHERSPOON. To give you the views on mining, when one has to decide how much ore is in place in a given ore body, you put down enough bore holes from which you can develop a meaningful evaluation of total ore. This is done all of the time. It is a standard technique.

Mr. BEREUTER. Is it possible to determine absolute consistency of a natural media, yes or no?

Mr. WITHERSPOON. Absolute consistency, meaning from whatever information I have, for certain I know all the details of that media throughout, say, an area of interest and be absolutely sure I understand that?

No, I don't think you can have absolute assurance.

Mr. BEREUTER. Thank you.

Is it possible to use some kind of acoustical or sonic techniques to determine consistency? Is it theoretically possible? I am thinking, for example, of a very different area, about CT scan on the human body determining differences in the characteristics of tissue, cavities, certain kinds of devices for measuring problems in cardiovascular areas. It is possible to use something like this to determine the consistency of a natural media?

Mr. WITHERSPOON. Yes. In fact, there is research right now on these applications of what are called ultrasonic—that is one approach—a various geophysical wave that can be projected out into rock masses looking for features that indicate the rock is not all one consistent solid, but has certain holes. That feature is currently being investigated.

Mr. BEREUTER. Theoretically, at least, it is possible then, we could have absolute assurance of the consistency characteristics—lack of cavities, for example—in a media?

Mr. WITHERSPOON. I am afraid I can't give you a good answer. I don't believe you can get, if I understand you, the absolute confidence you know every discontinuity in a rock mass.

Mr. BEREUTER. Isn't it certain then that you have less likelihood of discontinuity or, in fact, absolute assurance, perhaps, of the lack of discontinuity in a manmade media?

Let us take first more certainty, and then we will talk about absolute.

Mr. WITHERSPOON. I am afraid even manmade features—if you are thinking about concrete, for example, which would be a manmade kind of rock, even there, if it is a huge manmade piece of concrete, there may still be some discontinuity.

Mr. BEREUTER. I would agree with you that there may be.

Under careful test conditions and construction testing, isn't it more likely that you are going to have assurance that there are no discontinuities in manmade media than you are in natural media?

Mr. WITHERSPOON. I suppose so. I would agree with that.

Mr. BEREUTER. I thank the gentleman.

Mr. MARRIOTT [presiding]. We thank the panel very much. We do have a number of questions, but in lieu of time, we would like to have our staff write to you and get the answers to those questions in written form.

Thank you very much.

Our concluding witness for today will be Ms. Kathleen Bennett, Assistant Administrator for Air, Noise, and Radiation, Environmental Protection Agency.

You may identify the people with you, and you may go ahead and give your testimony.

[Prepared statement of Hon. Kathleen M. Bennett may be found in the appendix.]

STATEMENT OF HON. KATHLEEN M. BENNETT, ASSISTANT ADMINISTRATOR FOR AIR, NOISE, AND RADIATION, U.S. ENVIRONMENTAL PROTECTION AGENCY; ACCOMPANIED BY GLEN SJOBLOM, DIRECTOR, OFFICE OF RADIATION PROGRAMS, AND DAN EGAN, PROJECT DIRECTOR, HIGH-LEVEL WASTE PROGRAM

Ms. BENNETT. Thank you, Mr. Chairman.

Mr. Chairman and members of the subcommittee, I am Kathleen M. Bennett, Assistant Administrator for Air, Noise, and Radiation, the U.S. Environmental Protection Agency. I am pleased to be here to discuss the status of our program to develop environmental standards and radiation protection general criteria for the disposal of high-level radioactive wastes.

Before I begin, it is my pleasure to introduce Glen Sjoblom, who became our new Director of the Office of Radiation Programs last Thursday. I am looking forward to working with Glen as we enter a period of intense activity in developing criteria and standards for radiation protection. Also accompanying me today is Dan Egan, who is the project leader for our high-level waste program.

As you know the Agency has been working on these standards and general criteria for high-level waste for more than 5½ years. Their development has been both difficult and very different from any other regulatory task we have undertaken. In my testimony

today, I will briefly describe our program, and I will then address the five specific topics in which you expressed interest.

President Reagan's April 28, 1982, message to Congress on nuclear waste disposal reaffirmed the Federal Government's responsibility for safe and efficient disposal of nuclear wastes, and it called for a federally owned and operated permanent repository for disposal of high-level wastes to be available at the earliest practicable date. With your permission, I would like to offer the President's message for inclusion in the record of these proceedings.

Mr. MARRIOTT. Without objection, so ordered.

[President Reagan's message of April 28, 1982, to Congress, on nuclear waste disposal follows:]

THE WHITE HOUSE,
Washington, April 28, 1982.

Hon. THOMAS P. O'NEILL, JR.,
Speaker of the House of Representatives,
Washington, D.C.

DEAR MR. SPEAKER: The safe and efficient disposal of nuclear waste is an issue of profound concern to all Americans. I am pleased and encouraged by the reports of bipartisan Congressional activity regarding nuclear waste legislation.

I, and all my Administration, stand ready to work with you to proceed on a bipartisan and timely basis on this most important matter, so that the Federal Government can fulfill its responsibilities for safe and efficient disposal of nuclear waste.

I believe that we all agree that first and foremost in any consideration of this issue is the fundamental need to protect the health and safety of all our citizens. We must also mitigate possible harm to our environment. With these prerequisites in mind, I urge early legislative action so that we may clear the way for continued development of peaceful uses of nuclear energy.

On October 8, 1981, I announced several policy initiatives regarding nuclear energy. My Administration is currently working to implement these initiatives. Consistent with these initiatives, and in order to take advantage of the inherent efficiency in the private sector (benefiting the electricity ratepayer in the long run), nuclear waste legislation should be adopted soon, containing the following elements:

(1) A system of user fees to fund the construction and operation of high-level nuclear waste storage and disposal facilities.

(2) An appropriate and effective method for State governments to participate in resolving site selection issues involved in the licensing and deployment of waste disposal facilities.

(3) A temporary storage facility, financed from user revenues, to relieve the near-term problem of exhaustion of spent fuel storage capacity at some operating plants. This facility should be subject to appropriate limitations on quantity of fuel and time of residence, perhaps 5–7 years, to ensure that it cannot be a substitute for longer term and permanent facilities.

(4) A federally owned and operated permanent repository for disposal of high-level radioactive waste to be available at the earliest practicable date. A federally owned and operated monitored retrievable storage (MRS) facility should be considered strongly for long-term storage in the interim period prior to operation of a permanent repository.

(5) Application to civilian-generated waste only, since military nuclear waste will be addressed separately.

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To ensure efficiency and safety, nuclear waste legislation should require title transfer to the Federal Government, at a date certain, of vitrified high-level waste at the receiving facility. Alternatively, if vitrification facilities are not yet in operation, the Federal Government will take title to encapsulated spent fuel. This will fix responsibility and provide a firm basis for construction and operation of facilities for nuclear waste storage and disposal financed from user revenues.

These Federal actions are consistent with our basic effort to encourage private sector reprocessing in order to provide access to significant remaining fuel value for future generations as well as significantly reduce the volume of high-level waste.

The American people desire the safe disposal of nuclear waste. The necessary technology is available and scientific and engineering expertise exists to accomplish this goal. Federal legislation is required to assure a safe, effective solution for the disposal of nuclear waste at the earliest practicable time. I urge early consideration by both Houses of Congress and prompt enactment of legislation that will allow us to move ahead and deal with this issue in a timely and responsible manner.

Sincerely,

RONALD REAGAN.

Ms. BENNETT. The environmental protection requirements we are preparing will provide the basic objectives needed to guide development, demonstration, and licensing of the methods used to isolate these wastes. As you know, the Nuclear Regulatory Commission is developing detailed regulations that will implement our requirements, and the Department of Energy is responsible for designing, building, and operating the Federal repository. We are confident that this national program will provide the safe disposal of high-level wastes that the American people desire.

As currently drafted, our regulatory package for high-level waste disposal includes both numerical performance standards to limit long-term risks to the environment, as well as general radiation protection criteria designed to insure that disposal systems continue to provide protection far into the future. Our performance standards consist of limits on the amount of long-lived radioactivity that can be released to the environment for a disposal system. Our qualitative radiation protection criteria complement these performance standards by outlining a cautious approach for isolating these wastes from the environment for a very long time. For example, our criteria direct use of multiple barriers in designing disposal systems and call for use of sites that do not contain resources likely to attract future exploration.

As to the current status of our regulations, our standards and general criteria were submitted at the end of last year to the Office of Management and Budget for the regulatory impact review required by Executive Order 12291. We have been working closely with OMB and other Federal agencies to resolve some of the

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unique questions raised by this package. This review has not been completed yet.

During review under Executive Order 12291, NRC and DOE were asked to provide their views concerning our draft standards and general criteria. Both agencies raised some concerns about specific aspects of the package, and we have worked closely with them to resolve these issues. Although these interactions have taken extra time, they have resulted in significant improvements in our package. I believe this effort has been well spent. Recently, we have reached agreement with both NRC and DOE that our standards and general criteria should be promptly proposed for public review and comment without further changes.

With a regulatory package now ready for proposal, much of our work on this project is already done. From the time we started the effort through the end of fiscal year 1982, we will have expended about 50 staff-years and more than $2 million of contractual funds to prepare these standards and general criteria and the technical analyses that support them. In addition, in fiscal year 1983, we plan to use 10 staff-years and $500,000 of contractual funds to address the comments we receive on our proposal and to make any changes needed in our regulatory package.

Once we propose our standards and general criteria, we will need a relatively long public comment period, particularly because of the unique issues associated with this package. We plan to hold several public hearings to solicit these comments.

During the same period, the Agency's Science Advisory Board will conduct an intensive review of the technical analyses we use to develop our standards. This review will fulfill the commitment the Agency made to this committee in 1979 to obtain an independent evaluation of our analytical efforts before reaching any final conclusions about the protection provided by these disposal systems. We plan to promulgate our final standards and general criteria approximately 1 year after we propose the package for public review. However, there is a possibility that a somewhat longer period may be needed to evaluate and respond to the comments resulting from these public and technical reviews.

As I noted earlier, President Reagan has called for a permanent repository for high-level wastes to be available at the earliest practicable date. Because our standards and general criteria are an integral part of the national program, we have been closely involved with NRC's development of technical criteria for geologic repositories. We believe that NRC's proposed regulation outlines an appropriate and prudent approach for developing geologic repositories, and our close working relationship with NRC has insured that 10 CFR 60 is consistent with our draft standards and general criteria.

Accordingly, NRC's proposed technical criteria should provide the proper framework for DOE's site exploration and technology demonstration programs. Regarding actual licensing actions—when a promulgated 40 CFR 191 will be essential—the first license application for a specific site is not expected in less than 5 years, and I am confident that our standards and general criteria will be in place well before then.

In closing, Mr. Chairman, I would like to express this administration's commitment to carrying out the EPA responsibility with

regard to standards to proper control of radioactive materials. We are vigorously developing several other regulations, including standards for both inactive and active uranium mill tailings and for low-level radioactive wastes. I am particularly pleased with the results of our efforts on the high-level waste standards and general criteria. I am confident that they will provide the foundation for an effective national program for the disposal of high-level radioactive wastes.

Thank you, Mr. Chairman. We would be pleased at this time to answer any questions you may have.

Mr. MARRIOTT. Thank you, Ms. Bennett. I think the statement is very clear and succinct. We appreciate your coming before the committee to testify.

Mr. Bereuter.

Mr. BEREUTER. Thank you. I appreciate your testimony, too. I have no questions, Mr. Chairman.

Mr. MARRIOTT. I have no questions either. We received your testimony a little late and have not had a chance to develop any. We would like to leave the record open to have you respond in writing to a few questions that we will develop over the next several days.

Ms. BENNETT. We would be pleased to do so, Mr. Chairman.

Mr. MARRIOTT. Thank you very much.

Ms. BENNETT. Thank you.

Mr. MARRIOTT. We appreciate all of those who have testified today and for their input into this hearing.

The committee now stands adjourned.

[Whereupon, at 12:55 p.m., the subcommittee was adjourned.]

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APPENDIX

THURSDAY, JUNE 17, 1982

ADDITIONAL MATERIAL SUBMITTED FOR THE HEARING RECORD

TESTIMONY OF NUNZIO J. PALLADINO, CHAIRMAN, U.S. NUCLEAR REGULATORY COMMISSION

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE, MY FELLOW COMMISSIONERS AND I APPRECIATE THIS OPPORTUNITY TO APPEAR BEFORE YOU TODAY TO DISCUSS SOME IMPORTANT ISSUES FOR HIGH-LEVEL WASTE MANAGMENT LEGISLATION. TO BE MOST RESPONSIVE TO THE CONCERNS OF THE SUBCOMMITTEE IN YOUR INVITATION TO TESTIFY, MR. CHAIRMAN, OUR REMARKS TODAY WILL BE STRUCTURED TO ADDRESS THE TOPICS OF THE COMMISSION'S READINESS TO PROCESS A REPOSITORY LICENSE APPLICATION, THE PRE-LICENSING COMMUNICATION AND COOPERATION BETWEEN NRC AND THE DEPARTMENT OF ENERGY, REPOSITORY LICENSING SCHEDULES, AND THE COMMISSION'S ASSESSMENT OF FACTORS CRITICAL TO EXPEDITING THE LICENSING PROCESS.

COMMISSION READINESS TO PROCESS AN APPLICATION

THE COMMISSION ISSUED THE FINAL PROCEDURAL PORTION OF OUR 10 CFR PART 60 RULE IN FEBRUARY, 1981, AND WILL BE ISSUING THE TECHNICAL PORTION IN FINAL FORM THIS YEAR. THERE ARE, HOWEVER, TWO GAPS IN OUR PREPAREDNESS AT THIS POINT: THE LACK OF A GENERAL ENVIRONMENTAL STANDARD FROM EPA FOR HIGH-LEVEL WASTE DISPOSAL AND COMPLETION OF ARRANGEMENTS WITH THE DEPARTMENT OF ENERGY FOR GAINING EARLY AND CONTINUING ACCESS TO SITE TESTING INFORMATION AS IT IS DEVELOPED.

WE UNDERSTAND THAT EPA'S PROPOSED STANDARD IS COMPLETE AND READY FOR RELEASE TO THE PUBLIC FOR COMMENT. WE BELIEVE THE MAJOR

INTERESTED FEDERAL AGENCIES -- EPA, DOE, AND NRC -- HAVE WORKED OUT THEIR DIFFERENCES ON A STAFF LEVEL ON THIS PROPOSED STANDARD, AND WE BELIEVE IT IS FULLY CONSISTENT WITH THE NRC TECHNICAL CRITERIA NOW UNDER DEVELOPMENT FOR REPOSITORY LICENSING. THE DELAY IN ISSUANCE OF THE EPA STANDARD LEAVES UNCERTAIN THE FINAL RELEASE CRITERIA FOR THE REPOSITORY. WE WOULD HOPE THAT THIS CRITICAL PROPOSED STANDARD COULD BE ISSUED AS SOON AS POSSIBLE.

BEFORE DISCUSSING OUR CURRENT RELATIONSHIP WITH DOE, A SHORT EXPLANATION OF OUR APPROACH TO LICENSING UNDER THE 10 CFR PART 60 RULE MIGHT BE USEFUL. THE PROCEDURAL PORTION OF THE RULE WAS DESIGNED TO ASSURE THAT THE INFORMATION THE COMMISSION WILL NEED TO MAKE SITE-SPECIFIC FINDINGS FOR A REPOSITORY CONSTRUCTION AUTHORIZATION WILL BE GATHERED BEFORE THE LICENSE APPLICATION IS SUBMITTED. THE COMMISSION AVOIDED PLACING FORMAL PROCEDURAL REQUIREMENTS ON DOE'S PROGRAM AT THE SITE SCREENING AND CHARACTERIZATION STAGE, AND DOE IS FREE, WITHOUT FORMAL PROCEDURAL REQUIREMENTS, TO CONDUCT ALL THE NECESSARY ACTIVITIES TO CHARACTERIZE THE SITE FOR LICENSING, INCLUDING THE EXCAVATION OF SHAFTS AND LATERAL DRIFTS FOR TESTING AT THE PROPOSED REPOSITORY.

BECAUSE OF THE UNIQUE NATURE OF REPOSITORY DEVELOPMENT, MANY OF THE ISSUES THAT WILL HAVE TO BE SETTLED FOR LICENSING WILL INVOLVE RESEARCH AND SITE SPECIFIC INVESTIGATIONS WITH LONG LEAD

TIMES. THE COMMISSION HAS PROVIDED FOR AND URGED EXTENSIVE INTERACTION BETWEEN DOE AND NRC TO IDENTIFY POTENTIAL LICENSING ISSUES EARLY AND TO CONSULT ON THE PROGRAMS FOR RESOLVING THEM. WE DO NOT WANT TO WAIT UNTIL THE TIME OF LICENSE APPLICATION TO EITHER RAISE THE ISSUES OR TO WORK OUT WHAT IS REQUIRED TO RESOLVE THEM, SINCE THIS COULD RESULT IN SUBSTANTIAL DELAY.

NRC'S ABILITY TO CONDUCT A TIMELY AND EFFECTIVE LICENSE REVIEW IS LARGELY DEPENDENT ON THE QUALITY OF THESE CONSULTATIONS WITH DOE DURING THE PRE-APPLICATION STAGE.

TO PUT THIS IDEA INTO PRACTICE, THE NRC STAFF IN COOPERATION WITH DOE BEGAN A SERIES OF REVIEWS OF DOE ACTIVITIES BOTH IN THE LABORATORY AND AT THE POTENTIAL REPOSITORY SITES. IN THE LAST TWO YEARS, WE HAVE COMPLETED TWO THOROUGH REVIEWS OF FIELD ACTIVITIES AT HANFORD, TWO AT NEVADA, AND TWO REVIEWS OF THE SALT SITE SCREENING PROGRAM. WE HAVE ALSO PERFORMED REVIEWS OF KEY TECHNICAL DEVELOPMENT PROGRAMS SUCH AS GEOCHEMISTRY AND WASTE FORM. EACH REVIEW RESULTED IN A REPORT OF OBSERVATIONS AND SUGGESTIONS, AND A BRIEFING OF THE FINDINGS WAS GIVEN TO DOE MANAGEMENT.

ALTHOUGH THESE REVIEWS WERE CONSIDERED USEFUL BY ALL PARTIES, THEY WERE ONLY ANNUAL "SNAPSHOTS" OF THE SITE ACTIVITIES BASED ON

FORMAL DOE PRESENTATIONS. WE NOW HAVE REACHED THE POINT WHERE WE NEED ACCESS TO THE DATA BEING GENERATED AND MORE FREQUENT INTERACTION AS THE PACE OF THE NATIONAL PROGRAM PICKS UP. THIS IS SO WE CAN INDEPENDENTLY REVIEW THE DATA AND MAKE SUGGESTIONS ON THE DIRECTION OF THE SITE INVESTIGATION PROGRAMS WHILE THEY ARE IN THE FORMATIVE STAGES.

COMMUNICATION AND COOPERATION WITH DOE

THE STAFF REPORTS THAT ITS ATTEMPTS TO ESTABLISH AN ARRANGEMENT WITH DOE WHERE WE CAN HAVE CONTINUING ACCESS TO SITE DATA EARLY AND DISCUSS THE DIRECTION OF SITE INVESTIGATION PROGRESS HAVE NOT BEEN ENTIRELY SUCCESSFUL. NEVERTHELESS, UPON LEARNING OF THE STAFF VIEWS ON THIS POINT SECRETARY EDWARDS AND I AGREED THAT WE WILL WORK TOGETHER TO RESOLVE ANY DIFFICULTIES THAT MAY EXIST. ALSO THE STAFF RECENTLY HAD A NUMBER OF DISCUSSIONS WITH DOE MIDDLE MANAGEMENT AND HAVE BEEN ASSURED THAT DOE IS COMMITTED TO FREQUENT, OPEN CONSULTATIONS. BASED ON THESE DISCUSSIONS AND CONTINUED DOE AND NRC MANAGEMENT ATTENTION WE BELIEVE COMMUNICATIONS WILL PROVE SATISFACTORY FROM HERE ON.

LICENSING SCHEDULES

UNDER EXISTING LAWS AND REGULATIONS, WE ESTIMATE THAT OUR REVIEW OF AN APPLICATION FOR REPOSITORY CONSTRUCTION AUTHORIZATION, (OR

CA), WHICH IS A MAJOR STEP IN THE LICENSING PROCESS, WILL TAKE THREE-AND-A-HALF TO FOUR YEARS. THE GREATEST SOURCE OF UNCERTAINTY IS THE HEARING PROCESS, WHICH WE ESTIMATE WILL TAKE A YEAR AND A HALF IF IT GOES SMOOTHLY. THE NRC, WHILE MAINTAINING ITS RESPONSIBILITY FOR HEALTH AND SAFETY, WILL DO EVERYTHING WITHIN ITS STATUTORY AUTHORITY TO EXPEDITE THE LICENSING PROCESS TO MEET THE THREE-AND-A-HALF YEAR GOAL. HOWEVER, SOME POSSIBILITIES FOR DELAY ARE OUTSIDE THE COMMISSION'S CONTROL--THESE INCLUDE THE COMPLETENESS OF THE DOE APPLICATION AND ANY UNANTICIPATED TECHNICAL DIFFICULTIES THAT MAY ARISE FROM THIS FIRST-OF-A-KIND UNDERTAKING.

GIVEN THE POSSIBILITIES FOR DELAY, WE BELIEVE THAT THE SCHEDULES IN HR 3809, THE BILL REPORTED BY THE INTERIOR COMMITTEE, AND THE MAY 26 DRAFT BILL BY CONGRESSMAN OTTINGER ARE TIGHT YET REASONABLE.

EXPEDITING REPOSITORY LICENSING

THE COMMISSION BELIEVES THAT A MAJOR CONTRIBUTION TO EXPEDITING THE LICENSING PROCESS CAN BE MADE BY TAKING ALL NECESSARY STEPS TO ASSURE THAT DOE'S CONSTRUCTION AUTHORIZATION APPLICATION IS AS COMPLETE AND WELL-DOCUMENTED AS POSSIBLE.

VARIOUS BILLS NOW UNDER CONSIDERATION IN CONGRESS, INCLUDING H.R. 3809, ALSO HELP A GREAT DEAL TO EXPEDITE THE LICENSING PROCESS BY FOCUSING THE SCOPE OF NEPA ISSUES AND GIVING THE COMMISSION ENCOURAGEMENT TO MINIMIZE THE DUPLICATION OF DOE ACTIVITIES IN THIS AREA.

A NUMBER OF OTHER MEASURES TO EXPEDITE THE LICENSING PROCESS HAVE ALSO BEEN OFFERED IN VARIOUS FORMS, SUCH AS MANDATORY INTERIM REPOSITORY LICENSING. THE COMMISSION BELIEVES THAT MANDATORY PROCEDURAL SHORTCUTS ARE NOT ADVISABLE IN THIS FIRST-OF-A-KIND UNDERTAKING.

THESE REMARKS SUMMARIZE NRC VIEWS ON THE MAJOR POINTS OF INTEREST TO THE SUBCOMMITTEE, AND OUR DETAILED RESPONSES TO YOUR WRITTEN INQUIRIES HAVE BEEN PROVIDED FOR THE RECORD. IN OUR REMAINING TIME WE WOULD BE PLEASED TO RESPOND TO ANY ADDITIONAL QUESTIONS YOU MAY HAVE.

QUESTION 1. What is your current projected schedule for receipt and processing of a repository license application?

Answer.

Our understanding of the present DOE schedule is that DOE will submit an application for construction authorization (CA) to the Commission in 1988.

We estimate that under existing laws and regulations CA will take between three-and-a-half to four years. The greatest source of uncertainty is the hearing process, which we estimate will take a year and a half if it goes smoothly. The NRC, while maintaining its responsibility for health and safety, will do everything within its statutory authority to expedite the licensing process to meet the three-and-half year goal. However, a number of possibilities for delay are outside the Commission's control -- these include the completeness of the DOE application and any unanticipated technical difficulties that may arise from this first-of-a-kind undertaking.

These estimates are based upon the premise that DOE's application is complete and of adequate quality -- that is, that sufficient site characterization work will have been completed. As we understand it, DOE is seeking ways to expedite site characterization efforts, including limiting the scope of characterization itself. If this occurs, our review time for CA may increase due to a lack of necessary information upon which to base our licensing decision. We intend to coordinate our program with the DOE program to minimize the potential for these problems.

QUESTION 2. What, if any, submittals has the Commission received from the Department of Energy regarding site characterization or testing plans? What submittals are requested or required? What recommendations has the Commission made in response to such submittals?

ANSWER.

The only DOE submittals required by NRC regulations prior to license application are a Site Characterization Report (SCR) and subsequent semi-annual progress reports for each of the sites that DOE intends to characterize in detail.

We have not required any formal submittals beyond the site characterization reports. Instead, we are relying on more informal mechanisms for discussion and information exchange. While this sort of consultation is not required under our rule, practically speaking it is essential that NRC have at least a baseline of understanding about the site before the SCR is submitted if the staff is to be able to review it promptly. We have had recent management contacts with DOE and are assured they are committed to frequent and open consultation.

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QUESTION 3. To what extent are NRC and DOE cooperating in data gathering and verification plans and activities at potential repository sites?

QUESTION 6. What are the Commission's plans for assuring that data evaluation and verification methods are consistent with those of the Department?

ANSWER

Before we begin to discuss our current relationship with DOE, a short explanation of our approach to licensing under the 10 CFR Part 60 rule might be useful here. The procedural portion of the rule was designed to assure that the information the Commission will need to make site-specific findings for a repository construction authorization will be gathered before the license application is submitted. This would include extensive interaction concerning data evaluation and verification methods. The Commission avoided placing formal procedural requirements on DOE's program at the site screening and characterization stage, and DOE is free to conduct all the necessary activities to characterize the site for licensing, including the excavation of shafts and lateral drifts for testing at the proposed repository.

NRC's ability to conduct a timely and effective license review is largely dependent on the quality of consultations with DOE during the pre-application stage.

To put this idea into practice, the NRC staff in cooperation with DOE began a series of reviews of DOE activities both in the laboratory and at the potential repository sites. In the last two years, we have completed thorough reviews of field activities at Hanford Washington, Nevada Test Site and two reviews of the salt site screening program. We have also performed reviews of key technical development programs such as geochemistry and waste form. Each review resulted in a report of observations and suggestions, and a briefing of the findings was given DOE management.

Although these reviews were considered useful by all parties, they were only annual "snapshots" of the site activities based on formal DOE presentations. We have reached the point where we need access to the data being generated and more frequent interaction as the pace of the national program picks up. This is so we can independently review the data and make suggestions on the direction of the site investigation programs while they are in the formative stages.

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COMMUNICATION AND COOPERATION WITH DOE

The staff reports that its attempts to establish an arrangement with DOE where we can have continuing access to site data early and discuss the direction of site investigation progress have not been entirely successful. Nevertheless, upon learning of the staff views on this point Secretary Edwards and I agreed that we will work together to resolve any difficulties that may exist. Also the staff recently had a number of discussions with DOE middle management and have been assured that DOE is committed to frequent, open consultations. Based on these discussions and continued DOE and NRC management attention we believe communications will prove satisfactory from here on.

QUESTION 4. What formal or informal approvals or other authorizations are required by the Commission for DOE activities associated with site characterization or testing prior to construction permit application? To what extent can repository testing and construction work take place at a site without formal NRC authorization?

Answer.

No formal or informal approvals or authorizations are required under the pre-application review procedures of 10 CFR Part 60. These provisions were deliberately structured to give DOE adequate flexibility to develop the information needed to characterize a potential repository site without having to wait for NRC approval at each step.

Anything reasonably aimed at characterizing the site would be allowed, including the construction of as many as two shafts and the excavation of lateral openings at depth. Until the application is submitted, NRC did not choose to require DOE to conduct its site characterization program in a particular way, and DOE is free to reject NRC advice during the pre-application stage. In so doing, however, DOE may run the risk of further delay in obtaining the information the Commission will need for licensing, or may assume a greater burden of proof in demonstrating the safety of the site.

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QUESTION 5: What are the principal findings required by the Commission's high-level waste rule, 10 CFR 60.31? What tests and data are required to support these findings? (Please summarize.) How does the Department's current repository program relate to these requirements? What, if any, gaps can be perceived in the Department's current programs?

QUESTION 7: To what extent is at-depth site characterization required at potential repository sites? In what cases, if any, can a potential site be adequately characterized without at-depth characterization?

ANSWER.

Questions 5 and 7 address related points and are treated in the following discussion. For clarity, the response is broken down by detailed questions asked.

A. What are the principal findings required by the Commission's high-level waste rule, 10 CFR 60.31?

Under Section 60.31 of our rule, the Commission must find, among other things, that "there is reasonable assurance that the types and amounts of radioactive materials described in [DOE's construction authorization] application can be received, possessed, and disposed of in a repository of the design proposed without unreasonable risk to the health and safety of the public." Since the Subcommittee is most interested here in questions of site suitability and repository design, our response will focus on these areas.

Before authorizing construction, the Commission will have to make findings regarding: (1) the ability of the site and proposed design of the facility to provide long term containment and isolation of wastes, and (2) the ability to construct and operate the proposed facility so that the public health and safety are protected. The specific performance objectives and technical criteria that will be used in evaluating the site and design are to be delineated in 10 CFR 60 Subpart E (These were published in proposed form in July, 1981.) In general, we will need information about hydrologic, geochemical, thermal and mechanical properties and conditions of the host rock to make the required findings and supporting assessments.

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Specifically, evaluating the matter of long-term isolation and containment will require knowledge of groundwater conditions at the site--the rates and paths of groundwater movement. It will require knowing about the chemical conditions in the host rock and groundwater as they may cause reactions that effectively retard migration of any radionuclides entering the groundwater. Information is also required about hydrologic, geochemical and mechanical properties that will influence the integrity of waste containers and the waste form itself.
Based on these measured conditions, the behavior of the geologic and engineered containment systems as they are influenced by the heat of emplaced waste and potential disruptive natural events over thousands of years will have to be predicted. Thermal effects of waste emplacement will be a special complicating factor in such predictions.

Assessing the ability to construct and operate a facility will principally require knowledge of the mechanical properties of the rock--rock strength and stress conditions. We must find that stable openings can be maintained during operation so that the wastes can safely be emplaced and retrieved if unexpected conditions arise requiring this. As with the evaluation of long term containment and isolation, conditions determining the effects of waste heat on rock stresses and strength must be ascertained.

B. What tests and data are required to support these findings?

Because the specific issues will vary from site to site, investigative programs (data and test needs) will be site-specific. In general, site characterization will consist of a combination of tests conducted from the surface, in boreholes and in underground facilities excavated in the proposed host rock. Given the site-specific nature of the issues, NRC has avoided being highly prescriptive about specific tests that should be conducted. Instead, the NRC licensing proc[illegible]e provides a mechanism for the NRC and DOE to work together in identif[illegible]pecific issues at sites being examined and, with the opportunity for [illegible] involvement, establish what corresponding data and testing needs are. (More details on this are described in answers to previous questions.)

Also, such investigations will develop progressively. Like any investigative work, each step will depend upon what is learned in previous steps. Each step, while it will lead to reduction of uncertainties about issues identified earlier, inevitably leads to a different understanding of some issues or to discovery of new questions which must be answered. An approach which is aggressive from the start in flushing out problems that may exist at a site is essential to assure they are identified early, when there is still time to sort them out. Furthermore, this approach is essential if there is ultimately to be reasonable confidence that any signficant flaws have been uncovered. Other approaches which are based on the notion that site characterization is a process of confirming a set of optimistic projections about a site are likely to result in significant disruption and loss of public confidence over the long term when the unexpected is encountered.

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C. To what extent is at-depth site characterization required at potential repository sites?

On the strong advice from mining companies and experts, the Commission made the decision to require that underground testing be a part of site-characterization when it developed licensing procedures. We were advised that only very limited statements can be made about actual underground conditions critical to site-suitability and design from surface boreholes. One of the most significant factors which determines the hydrologic conditions and mechanical properties of rock is the degree to which there are fractures, discontinuities, and anomalous zones in the rock. Without creating large scale openings in the host rock, the presence and effects of such features cannot normally be determined with any confidence. Borehole testing is limited by the extremely small size of boreholes and the practical difficulties of testing at the great depths involved with repositories (thousands of feet below surface). Opening up rooms in the underground allows testing of representative volumes of rock and substantially eliminates speculation about significant variability of rock and groundwater conditions. We expect these facilities will involve construction of at least one exploratory shaft and may involve testing in 1000 feet or more of tunnels. Our specific observations are:

Hanford

Based upon our annual snap shot visits, we have been able to identify issues for specific sites under investigation that will only be resolved with confidence by underground testing. At the Hanford site, for example, there is a question about whether there will be rapid groundwater movement through extensive vertical fracturing which is a feature of the basalt (volcanic) rocks in which a potential repository would be located at the site. The question cannot be adequately resolved from surface boreholes. Until a shaft is complete and large rooms are opened, in the underground, we will not be able to measure the effect on an adequate scale to know with reasonable levels of confidence what its significance is. Another critical issue at Hanford involves a suspected abnormal stress condition in basalt rocks being investigated. Higher than normal horizontal stresses will require radically different designs of room openings than would normally be planned. This in turn will affect the design of waste packages. Again, only when large scale tests have been completed at the repository horizon itself will this matter will be resolved. As a consequence, a key part of the Hanford site characterization program is completion of underground tests.

Nevada Test Site

To resolve similar questions about hydrology and rock properties in tuff (volcanic ash origins) formations being examined at the Nevada Test Site, underground facilities are now planned. Also, construction of exploratory shafts and underground test facilities at the WIPP site are well underway to resolve similar questions before making final commitments to the site.

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Conventional underground construction and mining projects of repository scale routinely require similar studies to be performed prior to making any financial commitments. Moving from borehole data to at-depth exploration facilities results in information that can have decisive influence on site suitability.

D. In what cases, if any, can a potential site be adequately characterized without at-depth characterization?

It is conceivable but not likely that a case can be made for licensing without information from an underground facility. We are not aware of any site where this would be the case. However, in establishing the underground testing requirement, the Commission recognized that there may be situations where an underground facility may not be required. Opportunity was explicity provided in the rule for the DOE to request an exemption from this requirement, provided more limited testing could be shown to support the findings on site suitability which must be made.
There is no way to generalize on what kind of situation would permit such an exemption as the determining factors are site-specific.

E. How does the Department's current repository program relate to these requirements? What, if any, gaps can be perceived in the Department's current programs?

Because we have not yet reviewed the specific plans for detailed investigations at specific sites, it is difficult to comment on the adequacy of the DOE's current repository program. We have in the past raised issues with DOE's surface borehole investigations. Based on brief discussion this year on tentative, revised plans, we believe our previous concerns are being resolved. However, as such plans were tentative and conceptual we have indicated the need for followup discussion to make complete assessments. DOE and NRC management have met recently and have committed to prompt follow up discussions.

QUESTION 8. What activities contemplated by the Department's "Test and Evaluation" program contribute to site characterization and licensing? What, if any, T&E activities could detract from licensing activities?

Answer.

Test and evaluation activities could address follow-on considerations of design, materials emplacement, and personnel safety optimization. We do not believe that the Department's test and evaluation program would contribute significantly to site characterization. While these activities may be useful in firming up details of conceptual design for a license application, we do not believe that this second step should substitute for or interfere with the first step, which is determining the geologic suitability of the site.

In general, any research and development that relates to the specific geologic environment and its interaction with possible waste forms should be conducted in a potential repository environment. We believe some R&D activities, such as assessing the effects of heat and pressure on the intergrity of waste packages, could more easily and cost-effectively be conducted in the laboratory.

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QUESTION 9. What, if any, changes have been proposed or may be considered by the Commission in its current procedural rule for repository licensing?

Answer.

In developing the procedural portion of 10 CFR Part 60, the Commission structured its rule in such a way as to expedite the formal licensing proceeding by providing for an informal pre-licensing process. Under this process, the interested public and NRC staff could call attention to important issues and settle on measures needed to resolve them without encumbering DOE's flexibility to develop the information needed for licensing. In any case, the Commission sees no need for additional amendments to the procedural portion of our 10 CFR Part 60 rule at this time.

QUESTION 10 How can licensing of a repository be expedited? What steps has the Commission undertaken to expedite licensing?

Answer.

The Commission believes that the licensing process can be expedited by taking all necessary steps to assure that DOE's construction authorization application is as complete and well-documented as possible.

Various bills now under consideration in Congress, including H.R. 3809, the bill reported by the Interior Committee, also help a great deal to expedite the licensing process by focusing the scope of NEPA issues and giving the Commission encouragement to minimize the duplication of DOE activities in this area.

A number of other measures to expedite the licensing process have also been offered in various forms, such as mandatory interim repository licensing. The Commission believes that mandatory procedural shortcuts are not advisable in this first-of-a-kind undertaking.

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QUESTION 11. What is the Commission's view on the status of the Environmental Protection Agency's standard for operation of high level waste repositories, in the following respects:

-- The likely date of finalization of the standard.

-- The standard's consistency with or difference from NRC requirements under development.

-- The likelihood that an EPA standard will not be complete in a timely manner.

Answer.

We understand that the proposed EPA standard is complete and ready for release to the public for comment. The major interested federal agencies -- EPA, DOE, and NRC -- have worked out their differences at the staff level on this standard, and we believe it is compatible with the NRC technical criteria now under development for repository licensing.

QUESTION 12. What is the Commission's policy regarding how development and licensing of deep geologic disposal facilities should proceed in absence of a final EPA operational standard?

Answer.

If EPA standards are not issued soon, we intend to use our independent authority for protecting public health and safety under the Atomic Energy Act to establish permissible radioactivity release rates for an operating waste repository. We would begin this work as soon as we have promulgated the unaffected portion of our technical rule, which will be issued in the near future. If NRC were to undertake this effort it would require about 3 staff years and $750,000. We believe the development of permissible release rates would take a year and a half.

Hopefully EPA will promulgate this standard soon and we will not have to undertake this effort.

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STATEMENT OF DR. THOMAS A. DILLON
PRINCIPAL DEPUTY ASSISTANT SECRETARY FOR NUCLEAR ENERGY
DEPARTMENT OF ENERGY
BEFORE THE
SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS
U.S. HOUSE OF REPRESENTATIVES
JUNE 17, 1982

Mr. Chairman and Members of the Subcommittee, I am pleased to appear before you today to discuss the Department's progress and plans with respect to the development of permanent deep geologic disposal facilities for high level nuclear waste.

In my testimony, Mr. Chairman, I shall discuss the three issues of subcommittee concern that are reflected in your invitation letter to Secretary Edwards. Specifically, I shall address the Department's program schedule including the collection of relevant repository data, our efforts to interact with the NRC regarding facility licensing requirements, and our plans for implementation of NEPA requirements and interaction with host states. In the course of my testimony, Mr. Chairman, I shall also address the questions that were transmitted in your letter of invitation.

As you who have been working on waste management legislation know, there are many factors that could potentially affect the site selection schedule. These factors can be broadly grouped as follows: (1) program resources (both manpower and funding); (2) institutional processes (state and local relations, legislation, NEPA, etc.); and (3) technical findings. The siting schedule can be accelerated, maintained or delayed depending on these various factors.

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The current schedule for the Department's repository siting activities is described comprehensively in the Department's Position Statement in NRC's Waste Confidence Rulemaking. Briefly:

- The Department has selected a candidate site for detailed characterization on the Hanford Reservation in the State of Washington. A specific location for a principal borehole has been identified, and we plan to make a decision with respect to sinking an exploratory shaft during the coming year. Yucca Mountain has been identified as a second candidate site for further studies at the Nevada Test Site (NTS); a specific location for an exploratory shaft will be selected in FY 1983. Potential salt sites have been narrowed to the Gibson Dome area of Utah's Paradox Basin, the Texas Panhandle area of the Permian Basin, and four salt domes in the Gulf Interior Region in Louisiana, Mississippi, and Texas. A candidate salt site and exploratory shaft location selection is currently scheduled to be made in mid-1983. These sites could then be considered as candidate reference repository locations, pending determination of their suitability via detailed site characterization activities.

- Environmental assessments (EA) are planned to support the exploratory shaft location selection decisions and proposed detailed site characterization activities. An EA is expected to be completed on the Hanford candidate site in June of 1982, on the NTS candidate site by January 1983, and on the candidate salt site by the mid-1983 timeframe.

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- The Department currently plans to have available a site characterization report (SCR) for NRC and State review on the Hanford candidate site in September, 1982, on the NTS candidate site in June 1983, and on the salt candidate site in July 1983. NRC's procedural rule, 10 CFR 60, specifies that, based on DOE's SCR, NRC will prepare a draft site characterization analysis, will publish a request for public comments on it in the Federal Register, and, following a "reasonable period, not less than 90 days," will prepare their final site characterization analysis taking into account the comments received on their draft analysis. No time limits for the NRC review activities are specified in the procedural rule; however, we are not required to hold up any activity pending the review.

- Construction of exploratory shafts at the three candidate sites is scheduled to begin at Hanford by April 1983, at NTS by September 1983, and in salt by April 1984. We expect on our current schedule to have completed exploratory shaft construction at Hanford by September 1984, at NTS by July 1984, and at the salt site by September 1985.

The Department's reference program will sink a shaft at each site to the proposed repository horizon for at-depth site characterization.

There are no formal approvals or authorizations required by the Nuclear Regulatory Commission for activities associated with site characterization or testing prior to the Department's application for construction authorization. There are, however, a number of formal reporting requirements. The Nuclear

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Regulatory Commission's final rule on licensing procedures, 10 CFR 60, subparts A-D, requires the Department to submit a Site Characterization Report as early as possible after initiation of planning for a particular geologic repository operations area and prior to site characterization. In this Report, the Department is to describe the proposed site characterization program, including the extent of planned excavation and plans for in-situ testing. The Report will also contain a description of the decision process by which the site was selected including a description of the means used to obtain public, tribal, and state views. The Commission is required, by this same rule, to review the Report, prepare an analysis of it, and publish its analysis for comment by the general public and by state and local government officials. Following the comment period, the Commission is required to issue an opinion that they have no objection to the Department's site characterization program, or to list specific objections and recommendations.

We feel these formal reporting requirements will assure an adequate review of the Department's plans to conduct site characterization and testing activities prior to actual formal license application activities.

Preliminary activities include borehole drilling and associated downhole geophysical and hydrologic testing; repository construction is not included. The Commission's procedural rule prohibits the Department from beginning construction of a repository operations area until it has filed an application with the Commission and has obtained construction authorization from the Commission as provided in the rule. The information needed for the application, however, requires extensive site characterization, and the Commission's

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rule itself requires the Department to conduct a program of site characterization, including in situ testing at the repository depth, at the proposed site and at alternative sites. These site characterization activities will, of course, be reviewed by the Commission as discussed above.

The Department also feels that the repository licensing process can be shortened if the Commission is involved early in the Department's site exploration and characterization activities. The Department provides special briefings and data for the Commission on a regular basis. Commission staff members frequently visit the sites under investigation by the Department and are briefed on our activities. The Site Characterization Reports, which the Department will be submitting for each site, and the Commission's formal review of these documents, will undoubtedly provide an environment for extensive interactions well in advance of an actual license application. We trust these early interactions will smooth the path for licensing. Commission staff members have informally indicated that the reference license review time of four years might be shortened to three and one-half years providing the Department submits a very good application and no unexpected licensing issues arise.

The first draft site characterization report is now being discussed with the NRC. When the report is completed, we shall, of course, ask for Commission review as required by their procedural rule. In the meantime we continue to have interactions with the NRC staff and receive their comments on site characterization work planned or underway. As a result of some of these interactions we have incorporated changes in our planning and testing. For example, in November of 1981 NRC reviewed our plans for borehole drilling and

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testing at the Hanford Site and recommended that we add some paired-hole tests. After reviewing their recommendation, we changed our test plans and now intend to perform such tests. Our past experience with the Commission staff indicates they have talented personnel, and we have every expectation that their recommendations will be valuable to our program.

There are three findings which the Commission must make under 10 CFR 60.31 before it can authorize construction of a repository:

(1) Safety, i.e., that "there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a repository of the design proposed without unreasonable risk to the health and safety of the public."

(2) Common defense and security, i.e., that "there is reasonable assurance that the activities proposed in the application will not be inimical to the common defense and security."

(3) Environmental, i.e., that "after weighing the environmental, economic, technical and other benefits against environmental costs and considering available alternatives, the action called for is issuance of the construction authorization, with any appropriate conditions to protect environmental values."

The kind of tests and information needed to support these findings are basically of two types: (1) those which show that the site itself has geologic, geophysical, geochemical, and hydrologic characteristics that will

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provide adequate isolation of the radioactive material over the long term, and (2) those which demonstrate that the design of the repository, waste form, and waste package are adequate to contain the material over the short term. The first type of requirement we plan to meet by extensive geologic and hydrologic testing at the proposed site, and through the use of models which use data derived from these tests. We plan to meet the latter type by careful design and verification testing. The details of how the Department plans to comply with the requirements of the Commission will, of course, be contained in the license application.

We expect to provide NRC with information largely through reports of tests conducted from the surface through boreholes and through the results of in situ tests and investigations conducted during the exploratory shaft program. Such tests reveal the nature of the geology and hydrology of the site, and when used with other data and models can confirm the properties of the rock at the repository depth, the length of time it would take water to travel from the repository to the nearest discharge point, and even the effectiveness of the surrounding rock for filtering out radionuclides. Information also will be provided to NRC in the design documentation for the repository. Drawings and data will show the size of the rooms and pillars DOE is proposing for the underground repository, the size of the fans to move cooling air through the repository during the operational period, and other design data. Assessments of the adequacy of the design will also be provided, along with modeling studies of radionuclide transport and results of tests performed on waste containers under expected repository conditions.

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As currently envisioned, the Department's Test and Evaluation Facility (TEF) could provide some generic information affecting repository design and operations at an early timeframe in support of the first repository's operating license application. The specific objectives of the TEF are briefly as follows:

(1) Evaluate techniques and confirm the design of the equipment selected for handling, emplacing, and retrieving various types of waste in multiple barrier packages.

(2) Develop data base on techniques for control of occupational radiological exposures associated with repository operations.

(3) Confirm ventilation system design and performance.

(4) Evaluate instrumentation and equipment performance, and maintenance and reliability requirements.

(5) Develop the basis for scaling up to full-scale repository systems (e.g., waste handling rates).

(6) Develop and test operational procedures and administrative controls for routine operations and emergency or abnormal operations.

(7) Reduce repository design uncertainties through system performance evaluations.

The TEF is currently planned in the reference program to be located at one of the three candidate sites for the first repository. The technology to be verified and developed in the TEF will be somewhat independent of the repository host rock type; therefore, only one TEF is needed. The TEF will

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not address site-specific or host rock specific issues which will be resolved in parallel during the detailed site characterization phase at each candidate repository site prior to a license application.

Current requirements or limitations for TEF activities as contained in nuclear waste legislation are highlighted below.

S.1662

- Requires a site-specific proposal for at least one TEF by January 1, 1983 leading to January 1, 1988 operations. The proposal must be prepared in consultatiwn with NRC and EPA, and an Environmental Assessment must accompany it.
- An existing R&D site can be chosen for the TEF location, but the TEF must not be physically integrated into the repository.
- The TEF can receive and emplace no more than 300 packages of high level waste or spent fuel.
- NRC concurrence must be obtained in the TEF siting, design, construction, and operation, but the TEF will not be licensed.
- Provides for state/tribal participation in TEF siting, unless the site is an existing R&D facility that will not be expanded significantly.

H.R.5016

- The TEF is to be sited 30 months after initiation of repository site characterization at a candidate location and is to be located at-depth so as to focus site characterization at the most promising site.

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- The TEF is to be operational within 88 months after enactment, although construction cannot be underway prior to initial repository site selection.
- The TEF is to receive and emplace between 40 and 300 waste canisters.
- DOE and NRC are to enter into a memorandum of understanding for review, consultation, and coordination in planning, construction, and operation of the TEF. A similar agreement is to be established between DOE and the state/tribal government.
- TEF operations are to terminate no later than 5 years after initial repository operation.
- An EIS is required prior to proceeding with in situ tests using radioactive materials, while an EA is needed prior to excavating major shafts.

Your bill (H.R. 3809), as you know Mr. Chairman, contains no provisions for a TEF in the current version--nor does the House Energy Bill.

Turning now to the NEPA process, the Department's nuclear waste management program is structured for full compliance with NEPA. To this end, the Department has developed a NEPA implementation plan which is integrated with the overall planning and decisionmaking framework for the deep geologic disposal strategy. This plan was first introduced in the DOE Statement of Position filed in the NRC's Waste Confidence Rulemaking proceeding. It has been modified to reflect recent NRC requirements with respect to exploratory shafts, and is now found in the Public Draft of the National Plan for Siting High-Level Radioactive Waste Repositories and Environmental Assessment, DOE/NWTS-4 and DOE-EA151.

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The plan is a tiered approach which sets forth at each major decision point the level of environmental documentation that will be needed to support a decision. Presently, the plan calls for an environmental assessment for implementing the National Siting Plan referred to above, an environmental impact statement for the test and evaluation facility (if one is constructed), and an environmental impact statement for a repository site selection. This documentation is consistent with the DOE guidelines for compliance with the National Environmental Policy Act.

As to your interest in our interactions with involved States, DOE believes that the State governments and the public should have full access to all information regarding its siting activities. Though detailed conflict resolution mechanisms have not yet been enacted into law, mechanisms for working with State and local governments are established and used during the current phases of the waste management program. When State concerns about substantive and definable issues arise, DOE attempts to work out suitable accommodations so as to address these concerns, and, therefore, avert conflicts.

Twenty-five grants have been provided to State governments and State universities to permit their independent review of the DOE waste management program and to provide for workshops and meetings with the public. These important programs have provided a method for State officials to participate in our site screening programs and enabled members of the public to learn the essentials of the technology and of proposed programs. DOE also has an aggressive public affairs program aimed at keeping the public informed of the

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status of its activities through public meetings, reports, lectures, film strips, displays, etc. In addition, the draft National Siting Plan describes the process for selection of sites for a nuclear waste repository.

The Department is also committed to involving the public in the decisionmaking process leading to selection of a repository site. Public review and comment on all major DOE decisions is assured by the Department's implementation of the National Environmental Policy Act.

With regard to the licensing process, DOE is confident that the NRC will involve the public in much the same way that the public is involved in the licensing of nuclear reactors. Through public review of licensing documents and public hearings, NRC will assure that the public's views are considered. DOE will fully cooperate in that effort.

Let us now turn to your question on organization and projected manpower requirements. Based on current reorganization plans, the waste management program will remain a separate entity reporting directly to the Assistant Secretary for Nuclear Energy. In the proposed new organization, the Assistant Secretary will be responsible to the Deputy Secretary for Energy who will report to the Secretary of Commerce. If reorganization legislation is not enacted, the Department plans to continue the existing organizational relationship. There, as you know, the waste management program is under the Assistant Secretary for Nuclear Energy who reports to the Secretary through the Under Secretary.

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At present about 700 field personnel--40 DOE and 660 contract-- are involved in the initial site characterization program. Between now and the mid 1980's we project an increase of 400 personnel. Of this latter number, 20 are for DOE and the balance for contractors. These personnel will conduct site characterization work at three sites which involves the sinking of exploratory shafts and at depth testing at the candidate sites necessary to meet NRC licensing requirements. In addition, repository and waste package development and preliminary design for the specific host rock media will be conducted. These data, along with other site specific systems analysis for transport and site operations, will provide the basis of a license application for the first repository site in 1988. All of these activities will be centrally managed by a DOE headquarters staff of approximately 75 full time equivalent employees. We estimate an additional staffing requirement of 15 program personnel to manage the Nuclear Waste Trust Fund. Personnel for the remainder of the waste management program, remedial actions, Three Mile Island and West Valley, are not included in these totals.

This completes my formal statement, Mr. Chairman. I shall be pleased to answer any questions the Subcommittee may have at this time.

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TESTIMONY OF
JAMES F. DEVINE
ASSISTANT DIRECTOR--ENGINEERING GEOLOGY
U.S. GEOLOGICAL SURVEY
DEPARTMENT OF THE INTERIOR
BEFORE THE
SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT
OF THE
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS

June 17, 1982

Thank you for the opportunity, as a representative of the U.S. Geological Survey (USGS), to appear before this Committee to discuss various aspects of high-level radioactive waste disposal. I am accompanied by Eugene H. Roseboom, Jr., a USGS geologist, and John B. Robertson, a USGS hydrologist, both working on nuclear waste disposal, who will assist me in answering any specific questions you may ask. The attention given by this Committee to the problem of radioactive waste disposal is greatly appreciated.

I would like to begin by giving a brief overview of the Geological Survey's involvement with this subject:

The USGS is assisting the Department of Energy (DOE) in earth-science related portions of the National Waste Terminal Storage Program. Establishment of a mined geologic repository for nuclear waste involves major geologic and hydrologic questions which for the first time attach a practical significance to predictions of 10,000 years or more into the future. The USGS advises DOE by maintaining liaison personnel at DOE's Germantown, Maryland, Headquarters and their Columbus, Ohio, Office and by reviewing plans and reports of DOE's contractors. At the Nevada Test Site, we plan and manage

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the site exploration program for DOE. We are also conducting specific geologic and hydrologic investigations at various other locations being considered by DOE for high-level waste repositories in the salt dome regions of Louisiana and Mississippi, the Paradox Basin salt deposits of Utah, and the Hanford Reservation, Washington. In addition, the Geological Survey is conducting a cooperative effort with States of the Basin and Range Province of the Western United States to identify areas with high potential for possible repositories. We are also conducting research aimed at improving techniques for site identification and characterization and to improve capabilities to predict the consequences of geologic and hydrologic processes and events that could affect a repository. The USGS played a significant role in identification of the Waste Isolation Pilot Plant (WIPP) site near Carlsbad, New Mexico and continues to conduct hydrologic studies there. We also serve, from time to time, as technical advisors to the U.S. Nuclear Regulatory Commission (NRC) by reviewing reports and plans, contractors reports, and proposed regulations such as 10 CFR 60, currently under consideration. I say this to emphasize that the USGS is no stranger to the problems of exploring and characterizing a mined geologic repository for nuclear waste.

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The Committee requested information from the USGS on three major subject areas:

1. Our Assessment Of The Issues In Need Of Resolution At Sites Being Studied For Possible Development For High-Level Waste Repositories:

We are familiar and actively involved in studies at all currently identified site areas except the Palo Duro Basin of Texas. Although each site has unique and different unresolved earth-science issues which we will address individually, one common fundamental issue remains to be resolved at all the sites--a quantitative understanding of the subsurface hydrologic system. This issue is the cornerstone for assessing repository performance and suitability at all sites because the migration of radionuclides away from the repository is dependent on the flow and chemistry of ground waters. Specific aspects of this issue and others at each of the sites currently under study are as follows:

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Nevada Test Site

Present activity is focused on an area on Yucca Mountain at the western margin of NTS. At Yucca Mountain, there is a thick sequence of beds of volcanic ash, called tuff. The relatively strong variety, "welded tuff" offers potential for the construction of a repository. At present, four such welded tuff beds are under consideration, two of which are below the water table which is at about 1800 feet depth and two between the water table and the surface.

1. A major unresolved issue at Yucca Mountain is whether the transport time of radionuclides from a repository to the accessible environment will be sufficiently long to meet NRC and EPA requirements. The transport time depends on the ground-water flow path, its flow rate, and the amount of retardation or delay of nuclides due to their adsorption by clay minerals and other factors. Although ground-water movement appears to be generally understood in terms of its directions on a map, their paths in three dimensions and the rates of movement are poorly understood. It is also unclear what will constitute the accessible environment in this area since potable water is present, though at considerable depth. Placement of a repository above the water table should increase the transport time considerably by adding a significant barrier: a relatively dry subsurface environment.

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However, this concept has been seriously addressed only recently. There are a number of unanswered questions and NRC has not yet released regulations which would cover the zone above the water table.

2. A major issue which has been raised recently is whether the state of stress and the mechanical properties of the proposed host rocks will allow mining a repository at acceptable costs. These stresses might cause the rock to fail mainly along existing fractures, and it is possible that safe openings may be maintained only by expensive engineered reinforcements of various types.

3. One further issue is the complexity and variability of the physical properties and mineralogy of tuffs, which set limits on the temperatures to which tuff can be subjected and make it difficult to predict the overall behavior of a repository. Although rocks generally expand when heated, some tuffs contract because of mineralogical changes; this would affect both the mechanical strength of the rock mass and the rate at which water can move through it. In addition, most tuffs contain substantial amounts of pore water, which by migration through the rock matrix or fractures may significantly transfer heat. These problems are being competently addressed at several of the DOE National Laboratories: Los Alamos, Sandia, and Lawrence Livermore Laboratories.

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Hanford, Washington, Basalt Waste Isolation Program (BWIP):

Several geologic and hydrologic issues are in need of resolution at the Hanford site for possible development of a high-level waste repository. The most important ones relate to an inadequate understanding of the hydrologic system and the regional and local geologic stress conditions.

1. The path and traveltime of nuclides in ground water from a potential repository to the accessible environment is not adequately known. Both large and small scale tests of vertical permeability and effective porosity of the basalts and interflow zones are needed to calculate ground-water flow velocity. Measurements of the three-dimensional distribution of hydraulic head in the basalt sequence, which is also essential to determination of ground-water velocity and traveltime and direction of ground-water movement, are currently inadequate. For low-porosity, fractured rocks, such as basalts, this parameter becomes especially significant. There is a need to determine hydrogeologic boundary conditions, including ground-water discharge rates and locations along the Columbia River, in order to develop models of ground-water flow which simulate the real field conditions. The geochemistry of the regional hydrologic system needs to be determined to evaluate the potential mobility of nuclides.

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2. The state of stress in the rocks at the reference repository horizon needs to be determined. The types of fractures observed in the cores suggest the horizontal stress in the basalt may be high enough to have a direct influence on repository design and construction. Furthermore, stress induced fractures could provide new pathways for fluid migration and hence impair the adequacy of a repository to isolate the waste.

Paradox Basin, Utah

Present DOE activity is focused on a potential site in bedded salt at Davis Canyon, about 30 miles south of Moab, Utah, which was selected by a careful screening of the Paradox Basin.

1. The major unresolved issue is the hydrology of the area and what the transport time of radionuclides would be to the accessible environment. Information is very sparse; DOE has drilled a single well in the general area of interest and there are data from a few oil and gas exploration wells. There are several areas of known or possible past salt dissolution, all of which are more than 10 miles from the site. These need to be carefully evaluated as to their implications for the long-term future of the site. Additional drill holes and seismic profiles are planned to address these problems.

2. Another issue is the possible effects of the small amount of water within the salt beds present in pore spaces, in microscopic inclusions within minerals, and in hydrous minerals. It is well

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known that such water in salt would migrate toward a source of heat, such as the waste canisters. The amount of such water is difficult to determine. Prediction of its consequences in a repository is very difficult and there are disagreements as to the amounts of water that might migrate to the vicinity of a canister. It seems likely that this problem can be adequately bounded by sufficiently conservative assumptions, ultimately supported by in-situ heater tests. However, this could place very stringent requirements on the waste package, if it must be designed to deal with maximum amounts of brine that might conceivably reach the canister using the most conservative assumptions.

3. Still another issue, which can probably only be resolved by a shaft and underground workings, is the rate at which methane would move into the repository from the interbeds of black shale in the salt formation. This will primarily be a safety concern during the mining operations and operational phase in the same way that methane concentrations are an ever present safety concern in some coal mines. It does not, however, constitute a risk for the long term confinement of waste.

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Gulf Coast Salt Domes, Louisiana and Mississippi:

The primary objective in selecting potential sites is to find an environment where, with a minimum of disturbance testing and exploration, the subsurface geologic and hydrologic conditions can be inferred to provide adequate containment for the wastes. In other words, it is desirable that the rock and ground-water flow characteristics be relatively simple and predictable and can be evaluated without violating the containment properties of the site.

The Gulf Coast salt domes have resulted from the intrusion of salt from great depths into overlying sedimentary strata. Although the regional stratigraphy of the Gulf Coast is relatively simple, easily defined, and predictable, the process of emplacing the salt by intrusion has disrupted the strata in the vicinity of the domes and leaching of the salt during its emplacement has produced a caprock on the top and flanks of the domes. The principal geologic and hydrologic issues are as follows:

1. The structure of each candidate salt dome must be clearly defined. Their complex structure consists of folds, shear zones, and discontinuities in the salt dome, characterized by a predominantly vertical orientation. Shear zones formed during dome emplacement characterize the boundary between the dome and surrounding strata. These types of structures are potential avenues for vertical movement of waste-bearing fluids from the repository.

2. The caprock also represents a potential avenue for the movement of waste-bearing fluids from the repository into the surrounding strata.

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3. The existing stress field and the effects of the superimposed compressive thermal stresses produced by the wastes must be evaluated. These stresses can result in the enlargement of tension cracks at some distance above the repository level which could provide additional pathways for the movement of waste-bearing fluids.

Palo Duro Basin, Texas:

The USGS has not been involved in the study of this site area nor have we reviewed current progress or reports of those conducting the studies. We are, therefore, unable to discuss specific, unresolved technical issues.

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2. Our Assessment Of The Department's (DOE's) Program For Resolution Of Such Issues, And Of Any Testing Or Other Data Collection Not Currently In The Department's Program Which We Have Recommended Or Would Recommend Be Included:

We have a close and formal cooperative program with DOE and are confident they are aware of all the major identified, unresolved issues at each of the sites. Furthermore, we are familiar with their field studies and program plans and believe they address or have plans to address each of the major unresolved issues. How successfully and quickly these issues can be resolved remains uncertain, in our opinion. Answers to many of the questions require innovative new experimental procedures of large geometric dimensions and long time periods. Our experience in earth-science experimental field work has taught us to expect surprises and temporary failures before reaching final success. This means it is difficult to design all the tests completely in advance and to predict exactly how long each will take to yield needed results. Neither a repository nor a test and evaluation facility has ever been built, characterized, or licensed. The site characterization phases will be learn-as-we-go procedures. To add to the scheduling uncertainty, sociopolitical activities of States and public involvement can also impose unplanned delays in obtaining required technical information.

From a technical standpoint, we believe that the studies needed to obtain the earth-science information required for a construction authorization would take at least 3 years after an exploratory shaft and associated

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underground test workings are completed, assuming that all tests work successfully the first time and that there are no major technical "surprises." DOE has, what appears to be, an adequate program to answer the questions, given adequate time and resources.

DOE has often sought, and we have occasionally volunteered, our recommendations regarding their program. Generally, DOE has been responsive to our recommendations.

3. Our Assessment Of The Readiness Of The Nuclear Regulatory Commission To Evaluate The Data And Make Decisions Regarding A DOE License Application For A High-Level Waste Repository, And Any Recommendations You Have For Activities That NRC Should Undertake In This Regard:

The USGS is not in a position to make a formal assessment of the NRC's readiness to make an appropriate response to a license application. However, from our communication with NRC we know that staff members are aware of unresolved issues and are making an impressive effort to collect and evaluate information on these issues as it becomes available. The NRC has large and difficult responsibility. In order for any agency to properly carry such a responsibility, it is necessary, in our opinion, that they have early access to the technical data as they are collected, be able to observe the methods of collection and evaluation, and otherwise be kept well informed on the plans and progress of the site characterization programs. By virtue of having early access to the information, apparent shortcomings, unnecessary efforts, and other questions can be raised before major efforts, time, and expenses are wasted. We believe that

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the success of NRC in evaluating a license application will depend largely upon their success in obtaining and understanding the technical data as they are collected by DOE before the license application.

Summary

Although several major technical issues remain unresolved at all the sites currently being evaluated, there is no reason to think that the issues cannot be resolved with the DOE planned program, given adequate time and resources. Both DOE and NRC appear to be aware of the issues and the types of studies necessary to resolve them. The Geological Survey will continue to offer its earth-science expertise to help resolve this important national issue.

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TESTIMONY OF THOMAS A. COTTON

OFFICE OF TECHNOLOGY ASSESSMENT

Mr. Chairman:

My name is Thomas Cotton, and I am the director of the Office of Technology Assessment's study of commercial high-level radioactive waste management. Thank you for the opportunity to appear before this committee today to discuss some of the results of our assessment and to answer any questions you might have.

Our study focused on the relationships among all of the elements of a high-level waste management system, rather than on the technical details of individual elements, such as the specific tests involved in evaluating repository sites. Nonetheless, part of the analysis done during the course of our study did address aspects of the site evaluation process, and suggests some conclusions that may be relevant to the question that you are considering today. The results of that analysis are described in detail in the article which I have included as an appendix to this testimony. I would like to briefly discuss the approach we took in that analysis and summarize a few of its main implications.

This analysis I refer to was addressed to one specific queston: what can be done to give high confidence that a licensed and operating geologic repository will be available when you want it? This question immediately raises a second one: how many potential sites need to be evaluated to be sure of finding one or more that is suitable for a repository. If the answer to the latter question is that many sites have to be examined, then one either has to allow time to examine one after another, until a suitable one is found, or — if time is limited — one must be willing to examine a number in parallel so that backups are available to minimize the loss of time if one or more are rejected.

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The process of evaluating repository sites involves several successive phases of investigation, including the initial screening to identify potentially suitable areas, surface testing, in situ testing at repository depth using a shaft (generally referred to as characterization), construction, operation, and closure. In the early phases of site investigation, generic geologic studies are useful in screening out potentially unsuitable sites. In the later phases, however, site-specific investigations will be needed to produce detailed information concerning the host rock and its environment; a particular waste form, container, and engineered barriers; and any engineering features proposed for a particular repository. At each successive phase of site investigation, more complete information about the viability of a proposed repository can be expected. In some instances, this information will be used to reject a particular site from further consideration, while in others the data will result in greater confidence in the suitability of a site. Since these phases become increasingly expensive, particularly after excavation is begun, it becomes important to know how far along in this investigation process one must go to be highly confident that a site would be suitable for a repository.

Discussions with a small range of experts revealed a lack of consensus on this question. While some felt that a site that appears suitable after in situ characterization will have a high probability of making it all the way through the licensing proces, others believe that there may remain a substantial chance — perhaps 30 to 40 percent —that an apparently suitable site would be rejected at some point after submission of an application for construction permit. Because there is as yet no experience in actually characterizing, licensing, and constructing repositories (and since the final criteria and standards a repository must meet have not been adopted), this

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lack of consensus cannot be resolved at present and is simply a fact of life that must be considered in determining the appropriate approach for investigating sites for repository development. If the more optimistic view (Curve I in Figure 1 of Appendix A) is correct, there is little risk in quickly narrowing attention to several sites for in situ characterization. If the most conservative view (Curve II) proves to be correct, then there may be as much as a 30 percent chance that 3 sites carried into characterization might fail to produce a single operating repository; in this case the additional costs of characterizing more sites might be good insurance against that risk.

H.R. 3809, and other bills now under consideration by Congress, focus on the process of selecting a single site from the set of candidates now under consideration, and carrying that site through the licensing process. Thus the important question is how to maximize the probability of selecting a suitable site from among a more or less fixed set of alternatives in time to meet a mandated schedule. In contrast, our analysis posed the question of how large a set of alternatives must be examined in order to be sure that at least one is successful — a different question. However, our analysis does suggest several observations relevant to the question posed by H.R. 3809.

Since the number of sites now under consideration is fixed, the overall likelihood that one or more that is suitable for repository development will be found among them is also fixed. If there is a licensable repository there, you can find it sooner or later by trying to license them one at a time. This is probably the least expensive path (at least in terms of front-end costs), but it involves the risk of delays (and associate financial and political costs) if you do not pick a good site the first time. Since the 1998 target

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date for an operating repository contained in H.R. 3809 does not appear to allow time to try again if the first site submitted for licensing is rejected at some later point, it becomes particularly important to ensure that the best sites are selected the first time.

While our analysis showed a range of disagreement about how sure one can be that a site that looks good after in situ characterization will ultimately receive an operating permit, there was general agreement that the in situ characterization phase itself is one of the most important stages in determining the suitability of a site for subsequent development. Even if there were no NRC requirement for in situ testing before construction, DOE would certainly conduct such tests on its own before incurring the large costs of building a repository. A particularly important question, therefore, is how much time will be required in this phase to determine the information needed to justify the next step — submission of an application for a construction permit. If inadequate time is allowed at this stage before a site is selected for licensing, there is a chance that the site that would have the best chance of being developed into a repository in the long run would be passed over in favor of another less well-suited site whose flaws might not become apparent until later in the characterization process, after a choice had already been made.

The estimates developed for our study through discussions with DOE contractors (Table 1, Appendix A) indicate that from 4 to 6 years might be needed for in situ characterization, including the time required to sink a shaft to repository depth before tests are begun. The U.S. Geological Survey's "Plan for Identification and Geological Characterization of Sites for Mined Radioactive Waste Repositories" (U.S.G.S. Open-File Report 80-686)

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indicates that 3 to 4 years of tests at depth, once a shaft has been sunk, may be needed to provide enough information to proceed to construction. We have not seen studies that suggest that much less time at depth would be required, and the uncertainties about the time needed tend to go in the direction of how much longer it might take. For example, the need for some tests might not even become apparent until at-depth testing is already underway.

The current DOE reference schedule may involve some risk of premature dedcisions about which site to submit for licensing, since it allows only about 2 years for conducting tests at depth during site characterization once a shaft has been sunk and the necessary facilities prepared. Of course, data from 3 or 4 years of at depth testing would be available before a final NRC licensing decision even under the current DOE schedule, assuming testing is continued during licensing. However, selection of the site to submit for licensing on the basis of only 2 years of data could lead to discovery of information that would disqualify the site after it had been approved by the Presient and Congress and submitted to NRC, rather than before. The consequences of a rejection could be far greater in that case than if the site had simply been disqualified during characterization, and another site chosen for licensing. The schedule in H.R. 3809 accelerates the date for submission of a license application by about 1 year over DOE's schedule, and allows about 3 1/2 years from beginning a shaft for characterization to recommending a site for licensing. This could lead to further reduction in the time available for in situ testing before a site is selected for licensing, thus increasing the risk that information that might disqualify a site would be found during licensing rather than before.

Since we have no experience at actually characterizing a potential

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repository site and reviewing it in the licensing process — a process which itself has not been defined in detail —we cannot say how much a reduction of the time allowed for in situ testing will increase the chance that a site other than the one with the best chance of being licensed will be submitted to NRC. Indeed, there appear to be enough unresolved questions about precisely what will have to be done during in situ characterization that we cannot be sure that the chance of a mistake will be eliminated even if 3 or 4 years are allowed, since the estimates we have seen have been averages while the actual characterization process will be site specific. However, our analysis of the value of proceeding in parallel on more than one site suggests the potential problem could be reduced if DOE were simply to submit the two best sites for licensing simultaneously. In this way, even if continued testing during the licensing process reveals information that leads to the disqualification of one of them, the chances that this would occur with both should be substantially lower. The additional cost of submitting another site for licensing will surely be trivial compared to the costs that will already have been spent to characterize it in the first place, and the potential benefit could be avoidance of up to an 8 year delay that could result if licensing of a second candidate site was not initiated until the first was rejected.

Another step that could reduce the likelihood that inadequate information would be available at the time a site must be selected for licensing would be to rapidly develop an at-depth experimental facility that could be used to develop and test the procedures and analytic techniques which would later be used in site characterization and licensing. The repository development and licensing process is uncharted territory. The ability of a geologic repository to isolate radioactive waste for millenia cannot be directly demonstrated in the same sense that a new aircraft can be demonstrated to

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perform according to its design specifications. For this reason, there must be heavy reliance on predictions of the long-term isolation provided by the repository based on the use of mathematical models that embody scientific understanding of the behavior of the repository and its environment. Since such long-term prediction has never been done in a formal regulatory process, problems can be expected to arise the first time it is attempted. In addition, many analytic procedures to be used in the licensing process remain to be developed, including data collection and validation techniques, methods for verifying and validating scientific models, and the formal procedures for using such models to predict repository performance. Development of an at depth research facility to be used for resolving these uncertainties about procedures for demonstrating repository performance before site characterization is completed and the first formal licensing proceeding begins could avoid unnecessary delays at that critical stage of the waste disposal program.

For example, the Department of Energy could use such a facility to test the suitability of its site evaluation, facility development, and model validation procedures with respect to EPA and NRC requirements. The Nuclear Regulatory Commission could closely monitor the development of the facility in order to improve its understanding of the repository development process, to provide useful information for the development of procedures for reviewing applications for a construction permit, and in general to gain experience that would facilitate future licensing activities. This effort could even include a simulation of the entire licensing process at the test facility as a way of forcing early identification and resolution of the problems that could arise at each stage of the proposed repository licensing process.

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For the information and experience that could be obtained from such a facility to be of maximum usefulness in site characterization and licensing, the facility would have to be developed quickly — perhaps using an old mine as was done for the Stripa tests in Sweden. Use of an existing mine, which quite clearly could not ever become a repository, may have an additional advantage of allowing closer cooperation between the Department of Energy and the Nuclear Regulatory Commission than would be possible at a facility that could possibly be expanded into a repository, and might greatly facilitate the kind of simulation of the licensing process I have mentioned. I would note that some preliminary work has already been done for the Nuclear Regulatory Commission by Lawrence Berkeley Laboratory on identifying existing underground openings for in situ experimental facilities, and on designing such facilities and the experimental programs they would perform. For this reason it may be possible to proceed to implement such a test facility quickly.

Mr.Chairman, that concludes my remarks. I would be glad to respond to any questions you have.

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STATEMENT OF THOMAS A. COTTON

OFFICE OF TECHNOLOGY ASSESSMENT

Mr. Chairman:

My name is Thomas Cotton, and I am the director of the Office of Technology Assessment's study of commercial high-level radioactive waste management. I appreciate the opportunity to appear before this committee today to discuss the results of our assessment and to answer any questions you may have. I would like to draw on the results of our analysis to put some perspective on the policy question of establishing a schedule for repository development.

Perhaps the most important, and certainly the least expected, discovery of our study is that there is at least one combination of the policy options we evaluated that appears to be capable of achieving the broad support needed to bring an end to policy vacillation that has plagued the Federal high-level radioactive waste program in the past. At the heart of this policy is a commitment in Federal law to develop several mined geologic repositories on a firm and conservative schedule; and to contract with utilities to begin accepting waste at a repository on a conservative date when a repository is likely to be available.

A Schedule that is Both Firm and Conservative

A commitment in law to a firm, conservative schedule for repository operation is the keystone of the entire integrated policy. Both characteristics -- firmness and conservatism -- appear necessary if the policy is to obtain broad support. If either is missing -- if the schedule is optimistic rather than conservative, or flexible and open-ended rather than firm -- the history of the waste management program, and testimony on the bills under consideration by this Congress, strongly suggest that some

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affected group or another will be left seriously dissatisfied, and will have a strong incentive to try to change the schedule in the future. This could raise the risk of yet another repetition of the speedups and slowdowns that have plagued the repository program in the past, and call into question the credibility of a Federal commitment to any schedule.

Since the concept of a firm schedule seems to be generally accepted, let me discuss the importance of making it a conservative one. The basic reason for conservatism in a mandated repository schedule is the fact that there are unavoidable uncertainties about how long it will take to develop the first licensed, operating repository, and any failure to meet a mandated schedule will damage the credibility of the entire Federal effort. First, it is not certain how long it will take to get enough scientific and engineering data about a candidate site to be able to show that it is likely to meet EPA and NRC criteria and standards. Since the host rock formation of the repository, and the hydrology and geology of the surrounding site, form the principal barriers to the escape of the radioactive waste in the long run, geologic disposal depends upon confidence that these naturally occurring barriers will perform as desired over millen[illegible]. However, no geologic repository for high-level waste has yet been developed, and the regulatory criteria and standards that such a repository must meet have not yet even been established. As a result, there are understandably many unanswered questions about what tests will have to be performed, and what data collected, to demonstrate in the licensing process (which itself has not been developed and tested) that a site is satisfactory. For example, the Department of Energy has not developed detailed plans for the in situ site characterization phase, which is to be expected since the tests that are needed will depend to some extent upon which sites are selected for consideration. In fact, the need for some tests might

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not become apparent until in situ testing is already underway -- perhaps until well into the licensing process.

Second, there is the possibility that any particular site under consideration could be rejected at some stage of the site evaluation process, including the repository construction and operation phases. If there are no backups available when this occurs, there could be a delay of years while additional sites are brought through the licensing process. Even with backups, some delay may be unavoidable. For example, the Department of Energy has estimated that under current plans there would be a delay of about four years if one or more of the sites now under consideration for a repository proves unsuitable for characterization (Sen. Energy Committee Publication No. 97-62, p. 573). DOE is confident that this will not occur, and that the site they pick for licensing will be highly likely to receive a construction permit and ultimately an operating license. However, analysis performed for OTA during the course of our assessment (Appendix A) indicates that there is disagreement in the technical community about how much information about the ultimate suitability of a candidate site can be determined at each stage of the site evaluation process -- surface testing, in situ characterization, repository construction, and operation. While some experts feel that a site that appears suitable after in situ characterization will have a high probability of making it all the way through the licensing process (DOE's view), others believe that there may remain a substantial chance -- perhaps 30 to 40 percent -- that an apparently suitable site would be rejected at some point after submission of an application for a construction permit. Because there is as yet no experience in actually characterizing, licensing, and constructing repositories (and since the final criteria and standards a repository must meet have not been adopted), this lack of consensus in the

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technical community cannot be resolved at present and is simply a fact of life that must be considered in determining an appropriate firm schedule for repository development.

Risks of an Accelerated Mandatory Schedule

All of the waste bills now under consideration would require acceleration of the current DOE reference schedule for the first repository, which anticipates operation between 1998 and 2001. Yet even the DOE schedule can be seen as optimistic, since it appears to assume that everything will go right the first time -- that all of the technical and institutional processes go smoothly, without unanticipated problems (Sen. Energy Committee Publication No. 97-62, p. 564); and that the group of sites now under consideration is large enough to assure that one can be developed into a licensed and operating repository (Ibid., p. 573). A legislated mandate that DOE accelerate, or even simply meet, this already optimistic schedule in the face of the remaining technical uncertainties could cause several potentially serious problems:

First, it may lead to premature decisions (e.g., selection of the first candidate site, and NRC action on the license application) which could increase the chances that the final NRC action on the first site will be unfavorable. Considering the great political importance that is being attached to the first repository, the negative effects on public confidence of rejection of the first site selected for licensing could be severe.

Even the current DOE reference schedule may involve some risk of premature decisions about which site to submit for licensing, since it allows only about 2 years for conducting tests at depth during site characterization once a shaft has been sunk and the necessary facilities prepared. By

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comparison, the U.S. Geological Survey has estimated that about 4 years of actual testing at depth would be needed to obtain adequate information to permit repository construction (U.S.G.S. Open-File Report 80-686, p.49). While data from 4 years of testing would be available before a final NRC licensing decision even under the current DOE schedule (assuming testing is continued during licensing), selection of the site to submit for licensing on the basis of only 2 years of data could lead to discovery of information that would disqualify the site after it had been approved by the President and Congress and submitted to NRC, rather than before. The consequences of a rejection could be far greater in that case than if the site had simply been disqualified during characterization, and another site chosen for licensing.

The schedule in H.R. 3809 would accelerate the date for submission of a license application by about 1 year over DOE's schedule. This could lead either to selection of the sites for characterization on the basis of less data from surface testing; or to further reduction in the time available for in situ testing before a site is selected for licensing, thus increasing the risk that surprises would occur during licensing rather than before. Pressures for quick decisions about sites could also increase the chance that problems with a site would be discovered after, rather than before, it is approved for the next phase of investigation -- increasing the potential consequences of a rejection.

For example, the site at Lyons, Kansas that was selected by the Atomic Energy Commission in 1970 for development of a first geologic repository was abandoned two years later with serious repercussions because of technical flaws that were discovered after the site was chosen. The site was chosen in part because the investigations that would have been needed to prove out the

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acceptability of another site were expected to cause delay of two years, a delay which could have adversely affected the ability of the AEC to fulfill a pledge to Idaho that plutonium-contaminated debris from a fire at a weapons plant in Colorado would be removed from temporary storage in Idaho by the end of the 1970's. The abandonment of the Kansas site, and the related political controversy, created an atmosphere that was not conducive to further site exploration, and substantially delayed the repository program -- to the extent that the AEC proposed in 1974 to develop Retrievable Surface Storage Facilities for high-level waste to allow a period of decades for development of the first repository. Hindsight suggests that taking those additional two years to find other candidate sites as backups might not have been a waste of time, and might have resulted in speeding up the process of siting a repository in the long run. This experience suggests the value of allowing ample time for thorough investigations to detect potential technical problems with sites before they are formally selected for possible development, as well as the value of having backups available to ensure that unforeseen problems with the leading candidates do not lead to major programmatic delays and a loss of confidence in the Federal effort.

Second, slippage in the schedule could occur if deadlines simply cannot be met, which could place DOE in technical violation of the law. This could call into question the credibility of the entire schedule, and of the Federal Government's ability to manage radioactive waste -- particularly if the slippages occur in the early stages of the process when it is most important to begin building confidence in the Federal waste management program.

Third, contractual commitments with utilities that are based on a schedule which can only be met if everything goes right the first time will

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not be credible, and would not provide the utilities with the firm planning basis for interim storage that they need. In this regard, our analysis suggests that the certainty of the schedule for accepting waste from utilities is more important to the utilities than the speed.

Finally, an overly optimistic mandated schedule is likely to lead to opposition, rather than support, from those who believe more time should be allowed to resolve the remaining technical uncertainties and to work through any new institutional procedures that are established. Some fear that a firm schedule that does not allow ample time to resolve technical uncertainties could increase the risk that premature commitments to technologies and sites would be made and defended even in the face of problems that might develop later. This could lead to continued pressures for yet another slowdown of the schedule, such as occurred when the Carter administration -- responding to precisely such concerns -- adopted a much more cautious schedule for repository development than had been planned by the Ford administration.

These considerations lead us to conclude that the milestones in the current DOE reference schedule could best be used as non-binding goals for development of the first repository, which DOE would be expected to meet unless problems arise. However, a mandatory schedule, which DOE would be required to meet and which would serve as the basis for contractual commitments, needs to be more conservative, in the sense that it would allow for delays while additional data are acquired, as well as for the possibility that the sites now under investigation might not produce a licensed repository. Our analysis suggests that this possibility cannot be ignored. If the more conservative view of how far into the repository development process we must go to be confident that a candidate site is suitable proves to

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be correct, our calculations indicate that it may be necessary to characterize at least 6 or 7 sites, and carry 2 or 3 through the initial construction phase, to be highly confident of finding one that could receive an operating license. (Appendix A, Table 4.)

A conservative mandatory schedule could be based on DOE's best estimate of when an additional set of potential sites — other than those now being investigated -- could be identified and a second candidate site submitted to NRC and carried through the licensing process independent of the first site. In this approach, legislation could contain two sets of dates for the steps in developing the first repository: optimistic but non-binding goals, which would serve to focus DOE efforts in the near term and which could be met if one of the sites now under consideration proves acceptable; and more conservative requirements, which could be met even if problems are encountered with the first sites, because backups would be available from an entirely new and independent set of sites.

This approach -- which involves pursuit of two independent parallel paths towards a first licensed repository — is similar to the approach used by the National Aeronautics and Space Administration in planetary exploration missions in which it is crucial that an operating spacecraft reach a certain target by a firm deadline. In such missions -- such as the Viking mars landing and the Voyager mission to the outer planets — it is standard operating procedure to send two separate spacecraft to increase the chances that at least one will survive the trip in operating condition. If both spacecraft work, then additional data are obtained; if one fails, then there is still a good chance that the other will be able to complete the mission. While this increases the initial cost of the mission, it may be more

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appropriate in cases in which meeting a firm schedule is of crucial importance than would be the alternate approach of deferring development of a backup until problems develop with the first attempt -- an approach which holds down front-end expenditures at the cost of a risk of extended delays if a backup is needed.

According to DOE's current plans, two additional sites suitable for characterization could be identified by 1987, one selected for licensing by about 1992, and operations begun (assuming successful licensing) by 2005 or 2006. DOE also indicates that some acceleration would be possible if near term site-investigation budgets are increased, although they have not indicated precisely how much. Maximum conservatism could be achieved by allowing time to complete the screening of the Basin and Range province (province 9 on Appendix B) that is now being conducted by U.S.G.S., and perhaps the screening of several other adjacent provinces as well. This would provide a large pool of potential sites in the West chosen on the basis of a screening approach -- aimed at identifying suitable geohydrologic environments -- that is different from the approaches that have been used to identify sites to date, which have concentrated on use of existing DOE land (Hanford and NTS) or evaluation of geologic media (used for the bedded and domed salt sites now under consideration). (Western sites could be emphasized for the first repository because it may be easier to reach agreement about the suitability of a site located in an arid region the first time the licensing process is attempted; and because a Western repository would be desirable even if a second repository is subsequently sited in the East, to avoid cross-country shipment of waste from the reactors in the West. However, a legislated commitment to development of a second repository, and perhaps deferral of full-scale disposal operations until after a second repository is available —

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discussed further below -- may be needed to allay state concerns that the first repository would be the only one by default.) Analysis by the U.S.G.S. (Open-File Report 80-686, Figure 3) suggests that four provinces could be screened to identify potential sites for characterization in about 6 years, provided that sufficient manpower and funds were made available.

This approach would minimize the risk that highly visible legislated commitments -- and contractual obligations based on them -- could not be met. At the same time, inclusion of explicit goals for the steps for developing the first repository -- that can be used by Congress to hold DOE accountable for slippages that are not excused by technical complications -- could provide strong incentives for near-term progress that might otherwise be lacking with conservative commitment dates. Adoption of DOE's own reference schedule (rather than an accelerated one) as the basis for such goals would have the advantage of placing the full responsibility for the feasibility of the goals on DOE. At the same time, it should serve the purpose of stimulating a more disciplined planning and management approach than would be the case if DOE's schedule was not backed up by a clear Congressional intent that it be met if at all possible.

Pilot phase testing of repository operation

Allowing additional time for siting the first repository may not have to lead to an equivalent delay in beginning operation of the repository. Initial operation of the repository after issuance of a construction permit may be achieved earlier than the 5 to 8 years now contemplated by DOE if the approach proposed in 1976 by the Energy Research and Development Administration (DOE's predecessor) were used. That approach involved 5 or more years of pilot scale operations to evaluate handling and emplacement operations using hot waste and

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to confirm design calculations, using surface handling equipment and underground excavations that are portions of the full-scale facilities. While DOE plans for a 5 year checkout period involving excavation of only about 15-20 percent of the repository, this would follow construction of full-scale surface facilities. The 1976 ERDA approach would allow time for designs for the full scale facilities to be made final and the facilities built after, rather than before, substantial hands-on experience had been gained during the pilot phase of operations. It should also decrease the time required to begin the pilot phase using hot waste, and reduce the cost of extending the parallel-path approach through the initial construction and operation phases -- phases during which some experts feel there is a chance that a repository might be found to be unsuitable. Carrying two sites through licensing into pilot phase operations before incurring the costs of full-scale surface facilities would provide high confidence that at least one would be licensed for full-scale operation. At the same time, it would reduce the financial loss that could occur if a site were found unsuitable during the pilot phase after the surface facilities had already been constructed. In this regard, DOE analysis suggests that the waste packaging and encapsulation facilities at a repository could cost from $460 million to nearly $1 billion (DOE/NE-0007, p. III-79). If both sites were found suitable, it would provide 1) an opportunity to pick the best for full-scale development; 2) a backup in case the selected site develops problems later; and 3) increased confidence in the ability to find suitable disposal sites.

Schedule for Full-scale Operations

The possibiilty of a pilot phase of repository operation before the full-scale surface handling and packaging facilities are constructed suggests we

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clearly distinguish between the schedule for pilot scale operation of a first licensed repository using hot waste, and the schedule for full-scale commercial operation of a system of repositories. The objective of the first schedule is to ensure expeditious siting, licensing, testing, and demonstration of a geologic repository -- to answer questions about whether it can be done; the objective of the second is to serve as a basis for firm contractual commitments with utilities to begin accepting waste in an operational disposal system. Under current DOE plans, and the approach proposed in H.R. 3809, these two schedules are identical. Yet, there may be advantages to deferring the operational phase for an extended but fixed period.

First, it would allow for development of a final, optimized repository design for the full-scale system based on the experience gained during an extended period of pilot scale operations. This might allow relaxation of initial conservatism in repository design -- and a reduction in disposal cost -- if justified by the results of pilot operation and testing.

Second, it would allow time to site and construct a second repository before beginning to accept waste at high annual rates. This would allow lower handling rates at each repository, would ensure that contractual commitments could be met even if problems developed with one repository, and -- if an acceptable site for the second repository could be found nearer the bulk of reactors in the East -- could significantly reduce the costs and impacts of full scale transportation of high-level radioactive waste from reactors to disposal. In addition, assurance that full-scale disposal would not begin until a second site was located (perhaps based on a national site survey) could reduce fears that the first repository will be the only one, thereby

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reducing the political stakes involved in siting the first repository.

Third, it would allow more time to resolve questions about whether and when spent fuel might be reprocessed, so that the operational disposal system design can be based on better information about the relative proportions of spent fuel and high-level waste from reprocessing it would have to handle.

This suggests that the date for contractual commitments to begin accepting waste at a repository at full commercial scale (several thousand metric tons per year) be the date by which DOE would be required to have a second repository operational, allowing enough time for a national site survey so that there would be a good chance that an Eastern site could be found before waste began moving to a repository in large quantities. This would extend the NASA parallel-path approach all the way into the full-scale operational phase, thereby giving high confidence that contracts can be fulfilled in spite of remaining technical and institutional uncertainties. This would also be consistent with Federal repository development plans since 1976, which have contemplated full-scale operation of a second repository either at the same time as the first, or within several years.

Deferral of acceptance of waste from utilities at large-scale until a second repository is built would increase the amount of at reactor interim storage that would be needed. However, some spent fuel or equivalent high-level waste from reprocessing -- perhaps 10,000-15,000 metric tons in total -- would be needed for pilot scale tests at the candidate repositories, beginning on the mandatory date of pilot operation of the first repository or earlier (if all goes well with the first site submitted for licensing). Thus deferral of full-scale disposal operations until a second repository is on line would not preclude signing contracts to accept waste from some utilities when the

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first repository is operating at pilot scale. This would reduce the requirements for additional interim storage.

If utilities are expected to provide their own additional storage, the amount of Federal emergency backup storage that will be needed should be fairly insensitive to the date at which spent fuel could be accepted at a repository. The major source of demand for such storage would be those utilities that would exhaust existing capacity before 1991 or 1992 (by which time a new water basin could be made available unless there is some physical limitation on the space available for new facilities at the reactor site). However, the earliest that a repository might be available -- if everything goes right -- is the mid-1990's, even with the most accelerated schedule being considered. Thus, deferral of the date at which utilities could deliver spent fuel to a repository until a second repository is sited should have little effect on the need for Federal emergency backup storage capacity.

In addition, the increased costs of additional at-reactor storage could be offset by the financial benefits of delaying commitment of the high capital costs of construction of full scale facilities, and by any reduction in disposal costs resulting from extended cooling of the waste and optimization of the repository design based on pilot scale experience.

At the same time, deferral of availability of full scale disposal capacity much beyond thirty years from now would leave a rapidly growing number of utilities with decommissioned reactors with the lifetime discharge of spent fuel still stored on site. A target date of say 2012 for full-scale operation of the second repository would allow time for experience to be gained from the pilot phase of the first repository, even if none of the sites now under consideration work out and a site from the backup set must be

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used. Even if full scale operation does not begin until 2012, two repositories loading at 3,000 tons per year each could dispose of all the waste expected to be generated by the reactors now operating or under construction by about 2040, roughly 8 years after the last of those reactors would cease operation.

This suggests that three schedules be considered (see Figure 1):

Schedule I: Non-binding goals for development and pilot scale licensed operation of the first repository, which could be met if there are no major technical surprises and if one of the sites now under investigation proves suitable. Using the DOE reference schedule, the milestones could be:

1983 - selection of 3 sites for characterization
1988 - submission of license application
1992 - NRC decision
1997 - pilot scale operations begin.

Schedule II: Mandatory schedule for pilot scale operation of the first repository, allowing 5 more years than in Schedule I while 3 or 4 Western provinces are screened to identify potential sites:

1983 - Initiate expanded screening process
1988 - select 3 or more sites for characterization
1993 - submission of second licensing application
1997 - NRC decision
2002 - pilot scale operations begin.

Schedule III: Mandatory schedule for full-scale operation of two repositories, to serve as basis for contractual commitments with utilities. This would allow for completion of a national site survey using experience gained in the expanded province screening program included in Schedule II. The milestones could be:

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1993 - Select 3-6 sites for characterization, based on completed national site survey
1998 - submit one or more license applications for a second repository
2002 - NRC decision
2007 - begin pilot scale operations at second site
- if schedules I and II have produced 2 pilot scale western facilities, select one for full scale development
2012 - begin full-scale disposal oprations at two repositories, one in the West and one in the East, if suitably-located licensable sites can be found.

If Congress wishes to ensure that a parallel-path approach is used -- that additional sites are identified and characterized in a timely manner, that a second candidate is submitted to NRC for licensing to provide a backup for the first, and that a second repository is developed -- a legislated requirement to that effect may be needed to make certain that the necessary funds are made available. Unless there is a clear expression of Congressional intent that backup sites be identified and submitted for licensing independently of the first candidate site, there may be a tendency in later budget cycles to defer or eliminate such backups, which could be seen by some as unnecessary duplication rather than as prudent redundancy.

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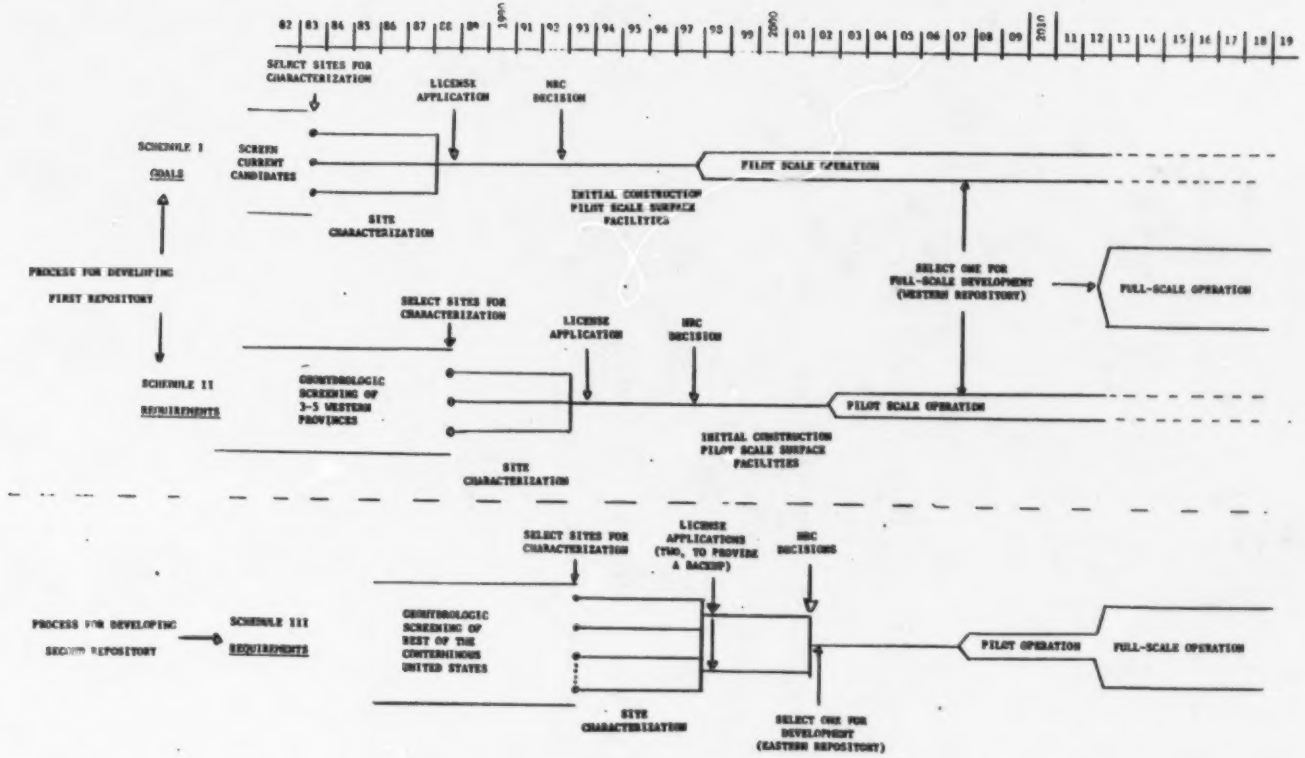
82 83 84 85 86 87 88 89 1990 91 92 93 94 95 96 97 98 99 2000 01 02 03 04 05 06 07 08 09 2010 11 12 13 14 15 16 17 18 19
SELECT SITES FOR CHARACTERIZATION
LICENSE APPLICATION
NRC DECISION
SCHEDULE I
GOALS
SCREEN CURRENT CANDIDATES
PILOT SCALE OPERATION
INITIAL CONSTRUCTION PILOT SCALE SURFACE FACILITIES
SITE CHARACTERIZATION
PROCESS FOR DEVELOPING FIRST REPOSITORY
SELECT ONE FOR FULL-SCALE DEVELOPMENT (WESTERN REPOSITORY)
FULL-SCALE OPERATION
SELECT SITES FOR CHARACTERIZATION
LICENSE APPLICATION
NRC DECISION
SCHEDULE II
REQUIREMENTS
GEOHYDROLOGIC SCREENING OF 3-5 WESTERN PROVINCES
PILOT SCALE OPERATION
INITIAL CONSTRUCTION PILOT SCALE SURFACE FACILITIES
SITE CHARACTERIZATION
SELECT SITES FOR CHARACTERIZATION
LICENSE APPLICATIONS (TWO, TO PROVIDE A BACKUP)
NRC DECISIONS
PROCESS FOR DEVELOPING SECOND REPOSITORY
SCHEDULE III
REQUIREMENTS
GEOHYDROLOGIC SCREENING OF REST OF THE CONTERMINOUS UNITED STATES
PILOT OPERATION
FULL-SCALE OPERATION
SITE CHARACTERIZATION
SELECT ONE FOR DEVELOPMENT (EASTERN REPOSITORY)

POSSIBLE SCHEDULE FOR DEVELOPING AND OPERATING TWO REGIONAL REPOSITORIES

FIGURE 1

SOURCE : OFFICE OF TECHNOLOGY ASSESSMENT

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APPENDIX A

Selecting a Repository Site

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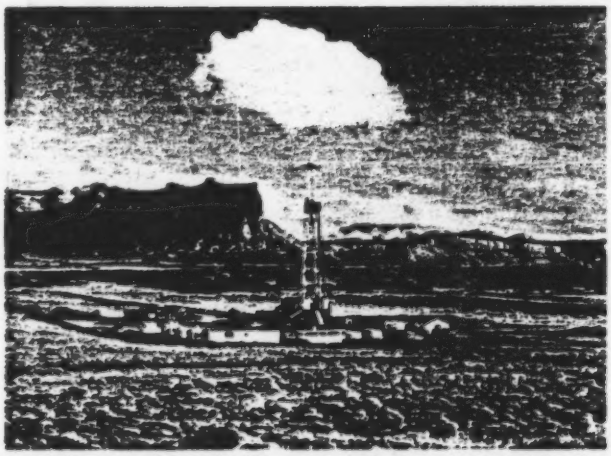

Deep drilling at various sites and in different types of rock will provide necessary information for selecting the site for a repository.

Selecting a site for the geologic isolation of high-level radioactive waste ought to start with an estimate of the ability to predict local conditions from general geologic considerations. Information from investigations during the various phases of site selection—site screening, surface testing, in situ testing, construction, operation, and closure—will serve to improve this ability. Let us assume that after each of these phases, to ensure a given level of confidence, we ask, "What is the probability that the site or repository under consideration could become an operating repository?" The answer to this question will reflect the knowledge accumulated at each phase, as well as the present reliability of geologic, geochemical, and geophysical predictions. For these reasons, the first section of this paper summarizes the present knowledge about regional and local geologic prediction, and some related knowledge gained from oil and mining explorations. It also summarizes some of the lessons learned and applies them to the problem of waste isolation. The remainder of the paper describes in broad terms the type of geologic testing involved in selecting a repository site and discusses a simple analytic scheme for estimating the costs of such a program. This scheme is based on a sequential accumulation of knowledge throughout the process of siting.

Adapted with permission from *Analysis of nuclear waste disposal and strategies for facilities deployment* (MTR-80W88), The Metrek Division, The MITRE Corporation, April 1980. This report was prepared as part of a study of commercial high-level radioactive waste management conducted by the Office of Technology Assessment of the U.S. Congress.

Geologic Prediction

All of the world, it can be said, is geologically mapped. Most of the United States is mapped on a scale detailed enough (about 1:500,000 or better) for us to focus easily on areas with the types of rock formations we are interested in—granite, shale, salt, and basalt. We can also project the thickness and volumes of these rock types. Furthermore, we know the state of past and current tectonic disturbance in any region and have information on the major mineral resource districts and areas that have been explored for oil and gas (see Harper and Szymanski on geologic characterization—Ed.). General geologic regimes are well enough known to estimate the sources and quantities of potable ground water and surface water.

It is difficult, however, to estimate the detailed quantitative characteristics of individual rock formations at a given site and the details of their stratigraphy (how beds or masses interfinger, disappear, and vary in thickness over an area) or the specific state of structural deformation (the degree of folding, faulting, or fracturing). All of this information must be obtained by detailed mapping on a local scale.

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Geologic maps are simply graphic representations of the distribution of a given rock property (for most maps the property is geologic *age*). As on other graphs, the lines drawn between different regions are interpolations between measured points—outcrops in the case of a geologic map, drill holes in the case of a subsurface geologic map. Maps of rock types such as granite, shale, and salt are based on field identification, and the names of the rock types are not precise terms. The properties of "shales" mapped in one area may differ greatly from those of "shales" in another region; the same bed may vary significantly within a local area, yet be mapped as one unit, implying uniformity. A formation or rock unit is named by its most abundant lithology, and the proportions of minor beds of other lithologies may not even be stated. This gross lithology is a large-scale lumping together of many rock varieties for the sake of convenience.

The variability of geologic parameters has been explored most fully by oil and mining companies. The oil industry has investigated a greater range of problems than the mining industry because of inherent differences in the kinds of geology they are concerned with, and because exploration efforts by oil companies have been more extensive.

In a typical exploration, an oil company targets a region for exploration and reviews all previously accumulated information on the region. This is a prelude to the acquisition of new information, much of which will be done by geophysical means long before the first exploration drill hole is planned. An exploration team can obtain a good understanding of the structure and stratigraphy of promising areas—some notion of oil and gas content, porosity-permeability relationships, clay content, and other properties. Sooner or later, however, the first hole must be drilled and detailed work-ups of the rock properties performed in the laboratory.

We know the most about an oil field, of course, when holes have been drilled and reservoir engineers have applied their knowledge about secondary recovery methods. At this point we should ask how and when most of the information was obtained. Much of what was known before the drilling began—the general geologic layout (structure and stratigraphy)—remains almost unchanged. Knowledge about the important rock properties, such as mineral composition and textures related to porosity and permeability, comes from the rock samples recovered from drilling. This is why reservoir geologists and engineers have emphasized adequate core samples. The number of necessary drill holes and samples depends on the variance of the property, which is a function of the kind of rock and its geologic origin.

Graph printouts from micro-earthquake monitoring stations provide data for characterizing potential sites.

The results in mining are much the same. Only after the mining has proceeded can one get the structural and geochemical data required to assess the shape and extent of the ore body or the coal bed. Many ore bodies in terrain that has undergone complex structural deformation reveal extremely fine details in systematic mapping at scales of 1:100 or 1:1,000.

Although our theories and methods for analyzing the data from these explorations may be powerful, they do not allow the prediction of details. It is necessary to examine promising rock types in order to ferret out important details. We can outline general areas where desirable rock types are found in tectonically undisturbed altitudes and where there is enough understanding of the conditions of origin of these rock types to serve as a guide in estimating the spatial distribution of rock properties.

Exploring Specific Sites

Granite, basalt, shales, salt formations, and tuffs are the major candidate rock types for a repository site (see Smedes on the DOE program—Ed.). These rock types all pose the same problem from the point of view of site selection—how to predict specific properties over a small, local domain without extensive drilling. Whereas the *general geometric patterns* of a host rock can be obtained by a well-conceived exploration program, the *specific rock properties* that directly affect the integrity of a waste repository are more difficult to measure and assess. Here the major questions are nuclide migration and changes of the related rock properties upon heating. We would like, for example, to know the ion-retardation properties of specific rock minerals for specific nuclides and to understand sorption as a function of temperature, pH, ionic strength, etc.

Experiments can be designed to map the surface reactions of nuclides with particular substrates; there are many radionuclides, however, and there may be a variety of substrates. To explore interactions among all the major radionuclides and an equally large number of possible mineral substrates would result in an n-dimensional matrix where n is a large number. We can never know all of this; the analytic task would be insuperable. The same is true for mapping hydrologic parameters. Were we to approach the problem by laying out all of the possibilities, we would end up with a large matrix of all the possible permeability-porosity relationships, pressure heads, and connected aquifers—again, an undertaking beyond our capacity.

There is no way, then, to approach

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these questions by applying a set of universal data. Rather, we must design an *ad hoc* selection scheme tailored to a particular rock type *and* to the area targeted for a site (see Hustrulid on host media—Ed.).

The initial objective of site exploration is to target for further investigation the areas which might host a repository site and which hold the most promise for an analysis of their rock properties. Four sets of characteristics are essential in defining a candidate site. In order of importance, they are:

- Tectonic stability against the hazards posed by earthquakes, volcanism, and associated phenomena. These conditions are easiest to assess geologically and can be met readily in the United States.
- A dry volume of rock which will remain dry or can be kept dry. Water can transport radionuclides, so it must be avoided. However, this does not imply that we need be restricted to arid regions. Because we know a great deal about water content in rock and can learn much more, this characteristic is also relatively easy to investigate.
- Maximization of ion retardation or minimization of radionuclide migration. Well-designed experiments can define this characteristic.
- Maximization of radionuclide-free water. Any radionuclides that have been transported must be diluted before entering the biosphere. This priority is probably the most difficult to satisfy. To the public it is the least acceptable aspect of a repository because, as soon as any amount of radiation is discovered in a public water supply, river, or lake, arguments arise about the safety of low levels of radiation. Because of its political sensitivity this factor should be recognized explicitly and emphasized in the site selection process.

To gather information for site development, several successive phases of investigation must be conducted, including site screening, surface testing, in situ testing, construction, operation, and closure. In the early phases of site investigation, generic geologic studies are useful in screening out potentially unsuitable sites. In the later phases, however, site-specific investigations will have to produce detailed information concerning the host rock and its environment; a particular waste form, container, and engineered barriers; and any engineering features proposed for a particular repository (see St. John on repository design—Ed.).

Minimizing Risk

At each successive phase of site investigation, more complete information about the viability of a proposed repository can be expected. In some instances, this information will be used to reject a particular site from further consideration, while in others the data and the model validations will result in greater confidence in the suitability of the site. The phases of investigation for a particular site are shown in Table 1. The table shows that the projected costs for geologic investigations increase significantly in the later phases of site selection.

There is no technical consensus as to which phase of investigation is most important in determining site suitability; various sequential learning alternatives and filtering processes were considered in this study. (Alternatives

Table 1. Site selection costs.

Activity	Description	Number of Sites	Cost Estimate (1980 dollars)	Time Estimate
Screening	Screening process beings with regions, narrows down to areas and then to locations	Variable	$4–6M	2–3 years
Surface testing	Surface exploration, borehole drilling, sonar and radar experiments performed to examine broadly a potential site	1	$30–50M	3 years
In situ testing	a) Construction of a single shaft (4-ft diameter) to a minimum depth of 250 m and a (20 ft × 20 ft) room at depth; possibly 10 (1,000-ft radial) borings; thermomechanical tests;	1	$25M	4–5 years
	or			
	b) construction of several shafts and drifts; more extensive physical exploration of the site than under (a).	1	$75–125M	5–6 years
Initial construction	Construction of 5–6 shafts, surface buildings, and approximately 15% of the underground mine (24 hrs/day, 360 days/year activity assumed)	1	$1.3–1.6B	5 years (salt) 7 years (granite)
Operation	Continuous construction of the repository facility and emplacement of waste; backfilling of emplacement rooms	1	$2.5B	25–40 years
Closure	Backfilling of shafts and sealing of repository	1		
Monitoring	Long-term monitoring	1		

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for sequential learning were discussed with geologists and earth scientists, who were asked to specify at which phase of the site investigation they would expect to have enough information to determine whether or not a particular site was suitable. The assumption was made that at the time of repository closure the total amount of information about the viability of a site would have been obtained. Thus, the estimates could be related to the fraction of the total information which would ultimately be obtained. The geologists and earth scientists were then asked to relate the fraction of information obtained to an estimate of the probability that a candidate site would eventually be considered a successful repository site.)

Since no repositories yet exist, the estimates, based on subjective judgments, spanned the range of values shown in Figure 1. The boundaries of the esumates are shown as idealized curves labeled I and II. Curve I corresponds to the situation in which most of the information needed to make a prediction about the ultimate viability of a site is obtained during site screening and surface testing; little information on which to reject sites would be obtained in subsequent phases. This represents an *optimistic* appraisal of the schedule according to which knowledge about the site can be obtained. On the other hand, curve II corresponds to a situation in which most of the information is obtained only at *later stages* of site investigation. Also shown is a dotted curve labeled A, which corresponds to a situation in which most of the information is obtained during the *site screening* phase; it is presented for purposes of comparison and discussion. This figure displays the range of uncertainty that must be dealt with in attempting to reach a consensus on the program for geologic repository investigations.

How many sites should be investigated at each phase to ensure at least one successful repository? To examine this question at each phase of the process, the individual site investigations were assumed to be independent of one another. (The independence of sites within the same geologic medium was also assumed, since they occur at different locations.) Thus, the probability of predicting success or failure at any phase of investigation was assumed to be independent of the number of sites examined.

The binomial distribution was then applied to the process of obtaining x successes in n independent trials, for an event in which p is the probability of success in a single trial, and q is the probability of failure in the corresponding trial. That is,

$$b(x,n,p) = \frac{n!}{x!(n-x)!} p^x q^{n-x}$$

As an example, consider the probabilities for obtaining at least one successful site:

$$b(0,n,p) = q^n$$

= probability of 0 successes;

therefore,

$$1 - b(0,n,p) = 1 - q^n$$

= probability of at least one success.

Pump testing and water quality determinations at drill sites help define the characteristics of confined and unconfined aquifers and water surface levels within areas being considered for repository sites.

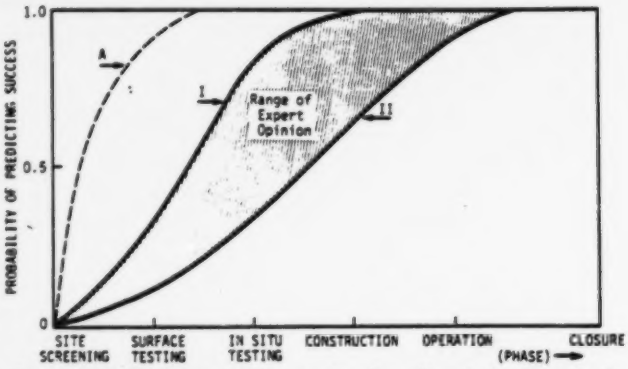

Figure 1. Probability of success in siting, at various phases of investigation. Curves I and II represent the limits of the opinions of a group of experts as to the schedule on which information needed to predict the ultimate viability of a site can be obtained. Curve I is a more optimistic appraisal than curve II. Curve A represents a hypothetical case in which disqualifying information is very unlikely to be obtained after the surface testing phase.

This process can be continued to obtain the probability for at least two or three successes, or any other desired distribution.

Table 2 shows the number of sites that must undergo each phase of testing to ensure *at least one success*, with a probability of 99%. The number of sites which are ultimately suitable may actually be larger than one. Combining Tables 1 and 2, we obtain the capital cost estimates (in millions of 1980 dollars) to ensure a 99% probability of at least one repository. This is shown in Table 3.

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Table 2. Number of sites that must undergo each phase of testing to ensure at least one success with 99% probability.

Estimate \ Phase	Site Screening	Surface Test	In Situ Test	Construction	Operation	Minimum Number of Successful Sites
A	Many sites	2–3	1	1	1	1
I	Many sites	15–16	2–3	1	1	1
II	Many sites	34–35	12–13	5	2	1

A = Hypothetical case in which the discovery of disqualifying information about a site is unlikely after surface testing.
I = Case in which the discovery of disqualifying information about a site is unlikely after in situ testing is completed.
II = Case in which the discovery of disqualifying information about a site is still possible into the operational phase.

Table 3. Cost estimates (in millions of 1980 dollars) to ensure at least one repository with 99% confidence.

Estimate \ Phase	Site Screening	Surface Test	In Situ Test	Construction	Operation	Total
A	4–6	60–150	25–125	1,250	2,500	3,750
I	4–6	475–750	50–400	1,250	2,500	4,300– 5,000
II	4–6	1,100–1,700	300–1,500	1,250	5,000	12,500–14,500

(Key same as Table 2.)

Table 4. Number of site investigations needed to ensure at least one success, with varying levels of probability.

Estimate \ Phase	Probability	Site Screening	Surface Test	In Situ Test	Construction	Operation	Minimum Number of Successful Sites
I	99%	Many sites	15–16	2–3	1	1	1
	95%	Many sites	10–11	1–2	1	1	1
	90%	Many sites	7–8	1–2	1	1	1
II	99%	Many sites	34–35	12–13	5	2	1
	95%	Many sites	23–24	8–9	3–4	1–2	1
	90%	Many sites	17–18	6–7	2–3	1	1

I = Case in which the discovery of disqualifying information about a site is unlikely after in situ testing is completed.
II = Case in which the discovery of disqualifying information about a site is still possible into the operational phase.

Table 2 shows that in estimate A, two or three sites would be investigated during surface testing but only one site from then on. Planning on this basis appears to cost the least; but the real world situation, in which social, political, and institutional interactions take place, may require more alternatives for siting. If a decision were made not to use the only available site at any point, and no other alternatives were available, the siting process might have to begin over. This would double the original cost, again without guaranteeing that the *second* site would prove a successful choice. It is also apparent that the projected costs following estimate I are not significantly different from those following estimate A. Thus, an increase in the number of investigations in the early phases does not appreciably increase the total cost.

Table 5. Cost estimates (in millions of 1980 dollars) to ensure at least one repository, with varying levels of confidence.

Estimate \ Probability	99%	95%	90%
I	4,500–5,000	4,200–4,500	4,000–4,400
II	12,500–14,500	7,200–12,250	5,625–8,000

(Key same as Table 4.)

Estimate II suggests that a larger number of investigations in the later phases of investigation will increase the total estimated cost. This early investment, however, could prove economical in the long run. Such a program might produce more candidate sites than had been expected at a particular phase of site investigation, and some of the sites could be "banked," or reserved for further investigation. A smaller number of sites would have to be investigated at the next major phase, which would reduce the overall cost. This approach would also have the ad-

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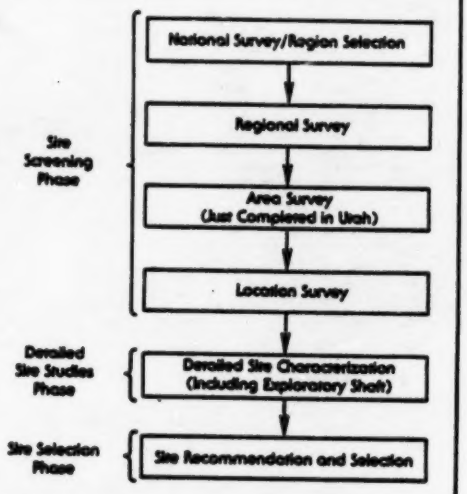
DOE'S SITE SELECTION PROCESS

The Department of Energy's concrete plan for selecting the first repository site for high-level waste includes several of the features recommended in the MITRE report (Ghovanlou et al.). DOE has established a hierarchical terminology to describe the process of narrowing the number of candidate sites until the final site is chosen. The **national survey** examined rock types with a potential for waste containment, including bedded salt. A **region** may include parts of several states. An **area** may be as large as 1,000 sq mi, and a **location** is tens of square miles. Finally, a **site** is a tract of land approximately 400 acres in size where repository surface facilities may be constructed.



vantage of keeping some potential sites in reserve if unexpected difficulties or delays were to arise.

Figures for varying levels of probability that at least one site will be found suitable have also been generated. Table 4 gives the number of site investigations required to ensure at least one success with varying levels of probability. If the desired level of probability is decreased, the corresponding number of sites that must undergo testing is also decreased. For example, if a probability of 90% is desired, the number of sites that must be tested at each phase to ensure at least one success is reduced approximately by a factor of two, as compared with the number required for a probability of 99%. The corresponding cost estimates for varying probability are shown in Table 5.

It should be re-emphasized that these estimates of the number of site investigations and projected costs are not predictions; they are presented solely to display the range of uncertainty encountered in planning for any repository siting program.

Final Observations

Limitations on the financial resources for isolating high-level radioactive waste make it necessary to choose an efficient method of site selection. To ensure the successful siting of the first few repositories for high-level waste, it would seem prudent to investigate several alternatives concomitantly. In terms of the total cost, parallel investigations in the early phases of repository development are significantly less expensive than in the later phases. Thus, the incremental expenses of investigating a large number of sites in the early phases is not large in comparison with the total cost of repository siting, through closure.

As the investigations move into the phases of in situ testing, construction, and operation, the same costs rise sharply. There may then be a tendency to reduce the number of alternative sites. However, since many localities may seek to avoid being chosen for a repository site, increased public opposition to a decision may be encountered at several of the remaining candidate sites once their number has been reduced (see the Public Policy section of this issue—Ed.). In addition, there may be serious impacts on the credibility of the isolation program if the first site to be selected for development is ultimately rejected and no back-up site is immediately available. In the long run, then, there is a trade-off to be made between the economic costs of carrying forward all the sites that pass the screening process and the political costs of selecting from a limited number of qualified sites. □

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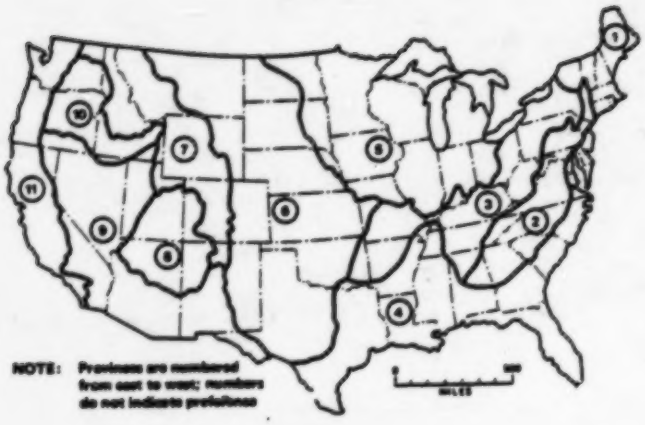
APPENDIX B


NOTE: Provinces are numbered from east to west; numbers do not indicate prevalence
EXPLANATION:
Suggested Provinces
1. New England-Adirondack Mountains
2. Appalachian Highlands-Piedmont
3. Appalachian and Interior Plateaus
4. Coastal Plain
5. Glaciated Central Platform
6. Western Central Platform
7. Rocky Mountain System
8. Colorado Plateaus
9. Basin and Range
10. Columbia Plateaus
11. Pacific Mountain System

GEOHYDROLOGIC PROVINCES AS DEFINED BY ESTP SUBGROUP 1

Source: U.S. Geological Survey. Plan for Identification and Geological Characterization of Sites for Mined Radioactive Waste Repositories. Prepared by Subgroup 1 of the Earth Science Technical Plan Working Group. Open-File Report 80-686.

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Testimony of

Paul A. Witherspoon

Mr. Chairman and Members of the Committee, thank you for this opportunity to testify on this important national matter. As you know, I provided testimony before this committee last July on certain aspects of the National Waste Management Policy Legislation where my experience in geological engineering was relevant. I appreciate this return invitation to provide you with my views on necessary and appropriate testing for the characterization and confirmation of geological sites for high-level waste disposal.

Geological engineers are being called upon to resolve technical issues central to the successful development of mined repositories. While I believe in the eventual success of the endeavor, I do not believe we are presently prepared to resolve all of the technical issues with professional certainty. Furthermore, I am concerned that present program plans do not provide the time and resources needed to prepare us technologically. Mr. James F. Devine of the United States Geological Survey has described the situation very succinctly in testimony that he presented October 6, 1981 before Senate Committees on Energy and Natural Resources and Environment and Public Works in connection with Senate Bill 1662. He stated near the end of his testimony, "The USGS believes that liberal time should be allowed to develop the necessary techniques and to acquire ample scientific information to support site selection decision and license application. Proceeding unnecessarily fast could lead to poor selection, site failures, license rejections, and wasted time and resources." I fully concur with Mr. Devine.

Geological engineering technology and expertise must address several key issues in the overall program during the particular phases of:

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- o repository site characterization
- o repository site confirmation

In terms of the DOE program and NRC licensing requirements these phases are viewed as distinct steps in the development of a repository. Site characterization precedes the construction license application and site confirmation occurs during the construction period and continues on into the operating period.

However, for the geological engineer, these two phases in the overall repository program are not separate. Rather, they are overlapping phases in addressing a progression of technical questions that need resolution to resolve the ultimate question of site suitability. In each phase, we investigate the geological make up, the physical properties, and the behavior of the rock formations. This is necessary because any rock mass on the scale of a waste repository is inherently complex with dynamic geologic and hydrologic forces in operation. A man made complication is introduced with the emplacement of heat generating, radioactive waste. The repository rock mass will be subjected to thermal loading, and the impact of this thermal loading on the mechanical and hydrological behavior of the rock mass is not fully understood.

Now, contrast this situation with a nuclear power plant where the component properties can be characterized in the laboratory, the design planning can be fully carried out by engineers, and the operational verification can be completed through standard commercial tests. Such an approach is not possible for a nuclear waste repository because the nature of the problems mandates a phased approach. Given the required tools and techniques, we will learn enough during the site characterization phase to enter the

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construction license process. Only during the subsequent construction and operation periods, can one confirm the nature and continued suitability of the site for waste disposal.

SITE CHARACTERIZATION

For construction license application, site characterization activities must, as a minimum, determine the inherent characteristics of the candidate rock mass to support the conclusion that the site is at least suitable for repository consideration. Much of the required information is routine in nature and its interpretation straight forward. However, access to the candidate horizon and some relatively limited excavations at depth will allow determination of the following factors that are crucial to the decision process:

- Homogeneity and lateral continuity of the candidate horizon;
- Nature, orientation, and extent of discontinuities;
- In situ state of stress;
- Vertical and horizontal permeability of the rock mass;
- Effective porosity of the rock mass;
- Size of the representative volume in the candidate horizon that contains a statistically significant sample of the rock mass for the purpose of estimating repository behavior.

Determination of these site characterization factors can only occur after one has access to the underground. Two shafts are required and I understand that with the fastest boring techniques now available, this will

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take about three years to complete in hard crystalline rock. To complete the site characterization work will require an additional three years to mine out the required rooms, implement the testing program and analyze the data collected. The total program for site characterization (i.e. shafts plus underground mining and testing) will thus require six years, and this is somewhat more time than is envisioned in the various House and Senate bills that I have seen.

One should bear in mind that the site investigation techniques and large-scale underground tests needed to determine the factors itemized above are not all completely developed. That some testing methods are still in the conceptual design stage is a danger to the program. The program needs proven techniques for measuring the magnitude and direction of principal stress components. Instruments and testing methods are not now available to define the hydrological parameters so critical to assessing a sites' suitability. Significant gains in these areas, which were made during our field investigations at Stripa, are now being incorporated into some specific site characterization plans. Other investigations have also helped improve the technological basis for site characterization work. However, much needs to be done to perfect the instruments and to establish the relevance of the testing methods. Such development of the needed tests and dry-run operations should be done soon; so that their validity can be established and their use at potential sites can be accomplished with known accuracies. The development of the first HLW repository in the United States is at the forefront of this developing technology, especially as regards the assurances mandated by the

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licensing process. I contend that the process will be smoothed and the programs' success improved through development and proof-testing of these new engineering methodologies before they are utilized at potential sites. This is especially important if the program's ambitious schedules are going to be adopted.

SITE CONFIRMATION

Even after the construction licensing milestone, a very important issue still faces any site that can only be resolved during the site confirmation phase. That issue involves determination of the rock mass response to the thermal pulse created by the heat that is generated by the emplaced waste. In my July testimony I noted that this topic must be faced as soon as possible in the program because the implications of this phenomenon can greatly affect a repository's integrity during operation. The thermal pulse will alter the physical and hydrological characteristics of the rock mass. It may also induce significant thermal convection because as groundwater comes in contact with the heated rock mass, there will be a tendency for the warm water to rise upward. The magnitude of this upward movement and the factors that contribute to it must be understood.

Theoretical studies have given us all kinds of scenarios. However, this work has not been validated, reflects no site specific data, and cannot be relied upon because the technical community has no direct experience to draw upon in predicting thermal effects and in assessing their implications on repository behavior. Both DOE and NRC are currently developing models that will be used to make long-term predictions of repository integrity and

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isolation capabilities. Such predictive work must be able to handle the coupling of the thermo-mechanical-hydraulic effects, but the engineering tests and experiments to make these models useful in the real world and to allow their application to specific situations do not now exist.

The tests required to determine repository response to this thermal load cannot be done quickly and certainly not within the timeframe of the construction licensing schedules. However, these tests can be started during site characterization and can continue on into the site confirmation phase. The approximate 6 year construction period should provide sufficient time to complete the tests, acquire the needed data, model the repository's long-term characteristics and determine its operational integrity. This assumes that the testing methodologies to determine the thermal pulse effects are available in a proven reliable form when needed.

Our work shows that to develop and verify the needed methodologies for this thermal problem will require at least five years. This work should start immediately and be vigorously pursued. Much of the effort must occur underground at a typical repository depth, but it cannot use repository sites because of scheduling. We should pursue this work in a generic sense, removed from site specific issues and schedules.

TEST AND EVALUATION FACILITY

The site specific activities now underway are progressing under what must be very difficult conditions, considering the limited resources and tight schedule constraints. I do, however, foresee real problems when

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they get underground and have to address technical issues without proven technologies. I am especially concerned that the TEF, while a worthwhile concept, will not be on line in time to contribute to the program in a meaningful way and may not be employed in an R&D program focused on the major technical issues to be addressed in the site characterization and site confirmation phases.

The TEF concept has been most completely developed in H.R. 5016, which has three principal components in support of repository site development:

1) Provide an unlicensed R&D facility for the development and verification of technologies, including testing methods and instrumentation,
2) provide a mock repository setting for testing and training in logistical areas such as waste handling and emplacement, and
3) provide space and facilities to investigate any site specific issues that may develop after construction license application.

The third component obviously must occur at the selected site and should be scheduled so as to complement site development activities. The various tests and site investigations will permit confirmation of repository design, verification of predicted operation characteristics, and formulation of the technical basis for the operation license submittal.

However, I fear the anticipated contributions from the first two components will be less than optimal if located at the candidate site, due to the attention that management must focus on site development and the necessity of maintaining development schedules. I would recommend that these two

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components be separated and neither of them should be carried out at a candidate site. The mock repository facility should be located at one of the existing federal facilities, such as the Nevada Test Site or the Hanford Reservation, where facilities for handling radioactive waste already exist. The R&D component should be organized as a generic test facility. I believe that separating the three components of the TEF concept in this manner is cost effective, consistent with the overall program schedule, and a prudent step to take at this point in time.

GENERIC TEST FACILITY

Specifically, as regards the Generic Test Facility, such a facility need not be licensed and could quickly be placed in operation because it can be located as an extension of an existing underground mine. The facility should be devoted to the R&D efforts needed to provide the technologies required for reliable site characterization and site confirmation tests. In the early stages, a Generic Test Facility should focus on the methodologies of measuring in situ stress, fracture geometry, bulk rock mass permeability, and effective porosity. Over the longer term, the facility would permit development of techniques to: (a) measure the coupled thermo-mechanical-hydraulic response of a candidate site, (b) measure the effects of excavation on the site's hydrologic integrity, and (c) develop methods of ultimately sealing a repository.

Results of the initial activities at the Generic Test Facility would then determine the types of tests and their interpretation that are required

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for the early stages of underground site characterization. Results of the longer term activities would determine the methods used to evaluate the response of the rock mass to the various perturbations (mechanical and thermal) that the repository will undergo. Concurrently, the Generic Test Facility would provide a test bed for the development of systems to monitor the response and integrity of the rock mass over long periods. Startup in an existing underground mine in calendar year 1983 would provide appropriate lead time to prepare characterization methodologies for application at the first sites now under consideration. The developmental work to support long range site confirmation studies could be appropriately phased in.

SUMMARY

To summarize, I believe we can adequately characterize geological formations to meet construction license criteria and that we will be able to credibly predict a repository's performance for operational licensing. However, to do so based on present geotechnical knowledge, using today's technologies and according to the proposed schedules, is not at all likely. I do not recommend delaying the program; it should be paced as fast as the administrative and engineering processes will allow. I do, however, strongly recommend an equally forceful parallel effort to develop the techniques and engineering know how that I believe are vital to the success of this program. Central to such a supporting R&D program is a generic at-depth test facility as I outlined today.

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KAISER ENGINEERS

TESTIMONY

CHARACTERIZATION OF SITES AND CONSTRUCTION OF MINED GEOLOGIC REPOSITORIES FOR NUCLEAR WASTE

Prepared for

SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT

of the

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS

UNITED STATES HOUSE OF REPRESENTATIVES

June 1982

Prepared by

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Manager, Mining and Geology Department
Kaiser Engineers, Inc.
Oakland, California

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KAISER ENGINEERS

INTRODUCTION

The U. S. Department of Energy (DOE) is examining the feasibility of constructing mined storage facilities for commercial nuclear waste in several types of rock including basalt, tuff, granite, and salt. The U. S. Congress is considering legislation to establish a schedule for the siting, construction, and operation of licensed mined geologic repositories for such waste. The testimony provided herein is in answer to a request by this subcommittee to provide information regarding underground exploration and construction activities at possible repository sites. The specific information requested was:

- A description of mining technology, existing and under development, suited or adapted to characterization and development of geologic sites for repositories, and an explanation of this technology in relation to conventional mining technology.
- A description of the appropriate excavations required for exploration and characterization of geologic formations for repositories, together with the appropriate safeguards associated with such construction.
- An estimate of the amount of time required to complete distinct site characterization and development activities.
- An estimate of the cost of mining engineering activities.

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MINING TECHNOLOGY

A perspective view of a conceptual design for a repository in basalt is shown on Drawing H-6-6004 "Mine Cutaway Perspective". From this drawing it can be seen that the planned repository consists of surface facilities for receiving and handling the waste; shafts to transport personnel, supplies, ventilating air, and waste from the surface to the subsurface facilities; a central shaft pillar; and a system of entries and storage rooms. While the planned repository is unique in its function, it does have many similarities to existing underground mines.

The construction of such a repository can be generally accomplished using existing technology familiar to the U.S. mining industry. There are, however, certain details of the construction which could benefit from some additional research and development.

Vertical Development

The shafts presently contemplated for exploring and developing a repository site in basalt at Hanford, Washington, vary in size from six feet in diameter, for an exploratory shaft, to 16 feet in diameter for a repository operations shaft. Since these sizes are finished sizes, the required excavations are necessarily larger to accommodate the requisite lining to support the walls of the shaft.

It is planned that the shafts for a repository will be sunk to depths of 2,000-4,000 feet. Shafts of the sizes and depths contemplated for a repository have been sunk in various mineral producing areas of the world. Various proven techniques are available for sinking such shafts and for equipping them with hoisting installations suitable for a repository.

Most large modern shafts today are sunk by drilling and blasting techniques with broken rock loaded mechanically into a conveyance for hoisting to the surface. Inflows of water can be handled by pumping, grouting, or freezing techniques, depending upon the quantities involved. Shafts are normally sunk with either a rectangular or circular shape, depending upon the circumstances, and the walls of the shaft can be supported by rockbolts, wire mesh, timber, steel, concrete, or may go unsupported if the ground is solid.

Shafts are also being sunk by mechanical boring methods either by enlarging a pre-drilled borehole by upward reaming or by boring a large diameter hole from the surface. In the first case, a preexisting opening underground is necessary to attach the bit and handle the cuttings. In the second case of blind boring, all work is done from the surface and the cuttings are flushed to the surface by air and water. Water inflows can be dealt with in a blind bored shaft by the use of drilling mud but water flows occurring in an upward reamed hole can be problematical because of the conditions caused by the water mixing with the cuttings and the subsequent handling difficulties underground.

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While most bored shafts in the past have been generally limited to the smaller sizes, recent technical advances in cutter design and drilling equipment indicate that this method may soon be in a position to compete technically and economically with conventional drilling and blasting methods for large diameter deep shafts in hard rock.

There are, however, shaft design and construction considerations which are peculiar to a repository and which do require further analysis. One of these considerations is the amount of disturbance experienced by the rock around the shaft opening as a result of excavation. While this disturbance is controllable for mining purposes, it is important to minimize it such that it does not become a pathway for possible radionuclide migration to the biosphere in the event of an accidental release underground. The extent of this disturbance in the various rock types is not adequately known at this time nor is the difference in the amount of disturbance caused by different excavation methods known except in a qualitative sense. It is likely that disturbance is less using boring techniques than drilling and blasting although controlled blasting techniques are available to limit this disturbance in the latter case.

A second consideration is the method of final sealing of the shafts when the repository is decommissioned. While this decommissioning is far into the future, the impact of the seals upon the shafts must be understood before final design of the repository. Otherwise, the design and construction of the shafts could be done in such a manner as to preclude the installation of a suitable seal.

Horizontal Development

The horizontal workings of a repository will consist of facilities near the shafts, such as shops, warehouses, offices, etc.; haulage and ventilation entries to and from the storage area; storage rooms; and storage positions within the rooms.

The sizes of these underground openings presently planned for the basalt repository program vary from 10 ft high X 10 ft wide for exploration drifts to 10 ft high X 20 ft wide for a storage room. Other repository designs, in salt for example, have considered storage rooms 20 ft high X 20 ft wide. Underground openings of these sizes have been constructed as part of mining or hydroelectric projects and are feasible for a repository.

Much of the horizontal work for a repository in salt and tuff can be accomplished by machine boring techniques. Such equipment is common in large underground potash operations, for example. In granite and basalt the choice between boring and drilling and blasting to advance the headings will primarily be a matter of economics, which will be affected by the opening configuration, storage room layout, labor costs, and the hardness of the rock.

While proven underground mine development and tunnel construction methods are available for the development of a repository, there are several technical considerations which merit additional study and testing.

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Long, small diameter, horizontal core holes could be very useful to explore an area proposed for a repository. There have been some examples of holes drilled up to 5,000 ft but the technology is still in need of further development.

Because the present plans for a repository contemplate simultaneous development of storage space and waste handling it will be necessary to continually probe ahead of an advancing excavation to avoid geologic hazards which are not otherwise discovered. This safety precaution is normally undertaken in mines, when required, by drilling a pilot hole ahead of the face. Work is being done to perfect geophysical sensing methods which could be used to improve the reliability of such probe holes in detecting hazards.

The two most common plans for the storage positions of the waste are vertical holes drilled in the floor of a storage room and horizontal holes drilled into the walls of the room. Horizontal storage offers economic advantages in terms of total excavation but testing is needed to verify the feasibility of boring large diameter holes, say 3 ft to 4 ft in diameter, over horizontal distances approaching 200 ft.

Ventilation

Nuclear waste stored in underground rooms will release considerable heat over the life of a repository. Because of the requirement for potential retrieval of the waste, the repository must possess the capacity to ventilate and cool storage rooms on an individual basis. In addition, the normal ventilation and air conditioning requirements of an operating underground facility must be met.

The ventilation and air conditioning system for a repository will be extensive, but similar systems are found in other large underground mines. The repository system, however, will need the capability to filter exhaust air in the event of an accidental discharge of radioactivity. This type of filtering equipment is available.

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EXPLORATION

The role and scope of an exploration program in nuclear waste repository design programs have been receiving increasing attention over the last few years as the National Waste Terminal Storage (NWTS) Program proceeds toward the goal of constructing and operating one or more nuclear waste repositories.

Since repositories are to be constructed in a geologic environment that has unknowns associated with it, the experience of the mining industry that has traditionally dealt with the underground structures and their problems should be examined and utilized where applicable in the repository program. While the application of the concept of "proving an ore body" for a nuclear waste repository differs in details from that for a conventional mine, the basic concept is valid, i.e. that sufficient detailed examination of the underground area in which the repository is planned to be built should be accomplished to prove that it has the necessary integrity before a final decision is made for the full capital expenditure program.

Exploration Program Definition

A minerals exploration program usually proceeds from a basic idea to the delineation of areas of ore deposition and ultimately a viable commercial mining project. An exploration program may proceed in the following sequence:

1. A study of known geologic conditions under which the final desired product is associated.
2. Delineation of favorable geologic areas for evaluation.
3. Field reconnaissance of favorable areas.
4. Definition of favorable areas by surface geological and geophysical methods.
5. Reduction of the target area by detailed geological and geophysical methods.
6. Drilling of exploratory core holes to confirm geologic and geophysical conclusions.
7. Physical entry into the selected area by shafts or adits to confirm core data and nature of deposit.

If all steps of the exploration program are positive, and the economics of the project are favorable, the decision is made to develop the property and place it into production.

Site selection and exploration programs for nuclear waste repositories are following a similar series of steps; the more advanced programs are generally in Step 6, and exploratory shafts to initiate Step 7 are being planned. Since the drilling of a large number of exploratory holes into a potential repository site is not desirable because the isolation capability of the site might be

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impaired, much of the exploration mapping of the site accomplished by a mining company from the surface under Step 6 must be accomplished for a repository by underground exploration under Step 7.

Applicability of Mining Industry Practice to the NWTS Program

While repository programs can draw from mining industry practice and major elements of mining exploration programs, differences between repository and mine development programs must be recognized. For a mine, the characteristics of the ore body itself and its immediate surroundings are of primary interest; however, for a repository, the exploration program must cover not only the waste storage area itself but also the surrounding region to confirm that the waste storage area will have the required degree of isolation and that potential changes in regional geologic conditions will not impair the overall integrity of the repository system. As indicated previously, there are also major differences in the extent of surface boring that is possible--exploration mapping for mines can involve boreholes from the surface on 200 ft to 400 ft centers, whereas this number of drill holes is not permissible for a potential repository site. Thus this element of a repository exploration program must be accomplished underground using tunneling and horizontal boreholes at the storage horizon.

Some have questioned why exploration mapping is necessary for a potential repository site. Based on experience over the years by the mining industry, conditions will be found that are undetectable from the surface. Such detailed exploration may detect conditions that would either make the site unsuitable or might require a change in the orientation or layout of the underground workings. Examples of such conditions for different media include,

for salt:

a) trapped brine
b) trapped gas
c) cavities or faults
d) excessive rock pressures,

and for hard rocks:

a) excessive water
b) excessive rock pressures
c) unacceptable faulting or folding
d) large areas of bad ground.

The application of mining practice to a repository program leads to a requirement for an underground exploration program at a potential repository site before the final decision is made to commit the major capital expenditures required.

Applications to Nuclear Waste Repository Design Programs

Plans for underground exploration programs have been developed as a part of the conceptual design of two repositories, the National Waste Terminal Storage Repository-2 (NWTS-R2) in bedded salt and the Nuclear Waste Repository in Basalt (NWRB). These plans both include exploration mapping of the potential repository site as the final step of the underground exploration program.

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NWTS-R2

This conceptual design includes a 1,950 acre rectangular waste storage area measuring approximately 10,000 ft X 8,600 ft and located 2,000 ft below the earth's surface in bedded salt.

The exploration program proposed in this conceptual design provides for:

- o an exploratory shaft
- o an exploration drift extending from the bottom of the shaft through the 10,000 ft length of the prospective waste burial area
- o horizontal exploration drill holes from and perpendicular to the exploration drift on 1,500 ft centers along the axis of the future waste storage rooms.

NWRB

The subsurface facilities layout developed during the conceptual design of NWRB encompasses a 1,900 acre area approximately 2 miles long by 1½ miles wide, in a basalt flow approximately 3,700 ft below the earth's surface.

The exploration program planned in this conceptual design provides for:

- o an exploratory shaft to the reference repository horizon for site characterization, followed by
- o tunnels and horizontal drill holes for repository design confirmation in and adjacent to the shaft pillar, and subsequently
- o exploratory mapping of the storage horizon over an area equivalent to that area needed for at least the first five years of waste receipts.

Sketches of the proposed exploratory shaft and a drawing of the proposed exploratory program are provided for reference.

With regard to the exploratory shaft (ES) at Hanford, Washington, a nearby borehole is being drilled through the next competent flow below the reference horizon prior to the start of shaft construction in order to obtain site-specific stratigraphy, hydrological data, and geotechnical information needed to determine the shaft depth, to locate test portholes, and to provide the overall site-specific data required by the shaft designer. This borehole will assure the overall suitability of the site selected for the shaft and will be used to obtain baseline hydrologic data prior to and during shaft construction.

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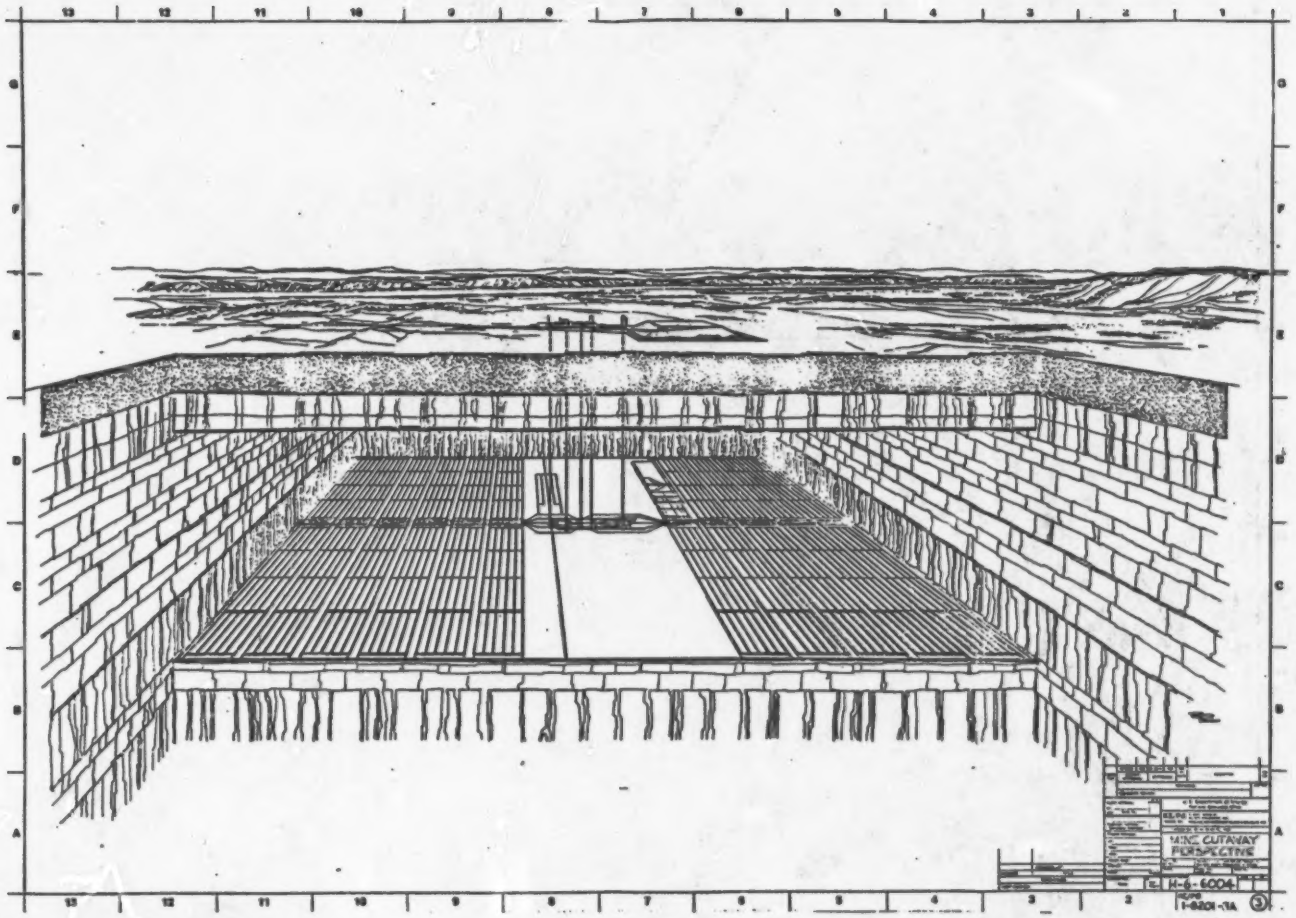

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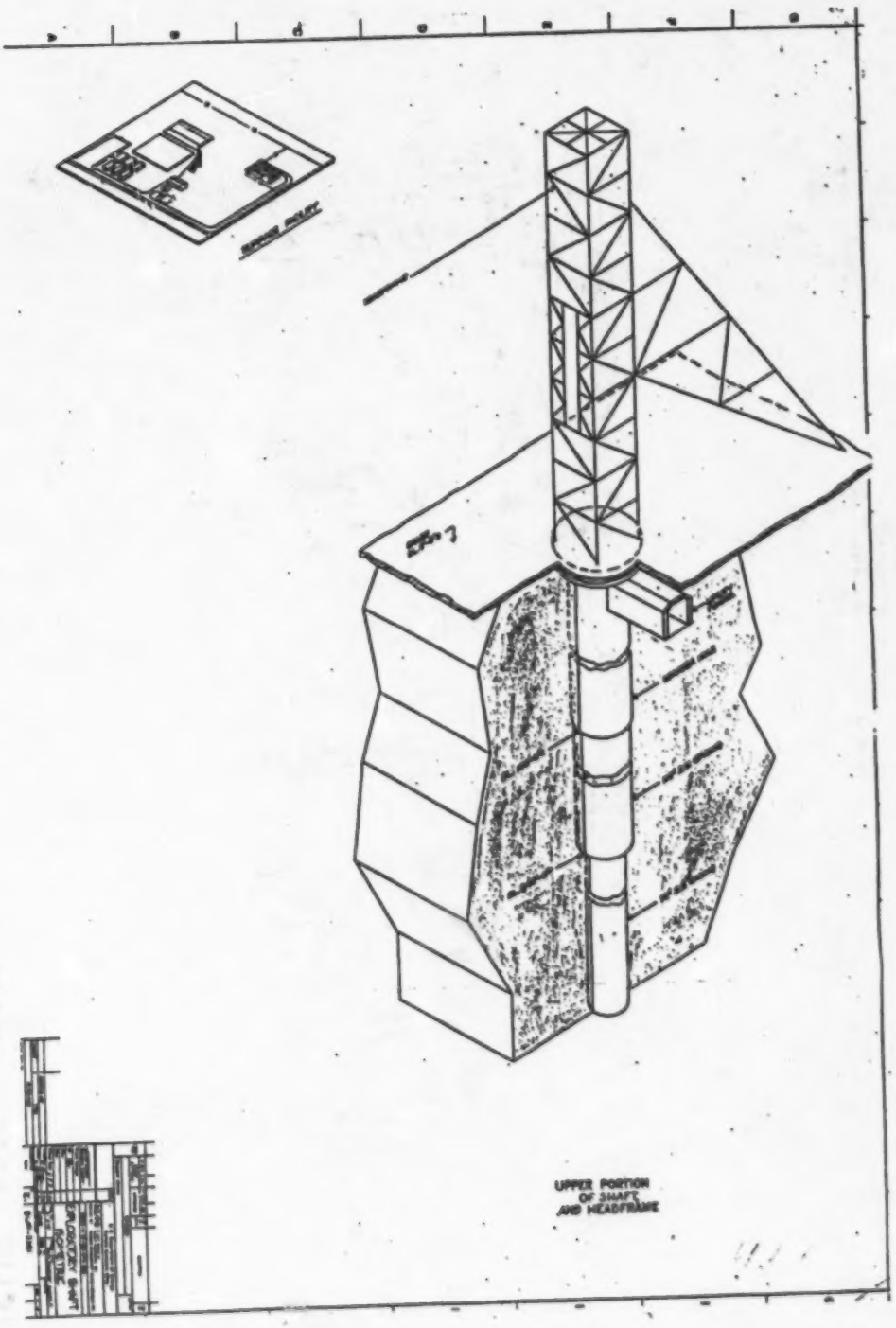

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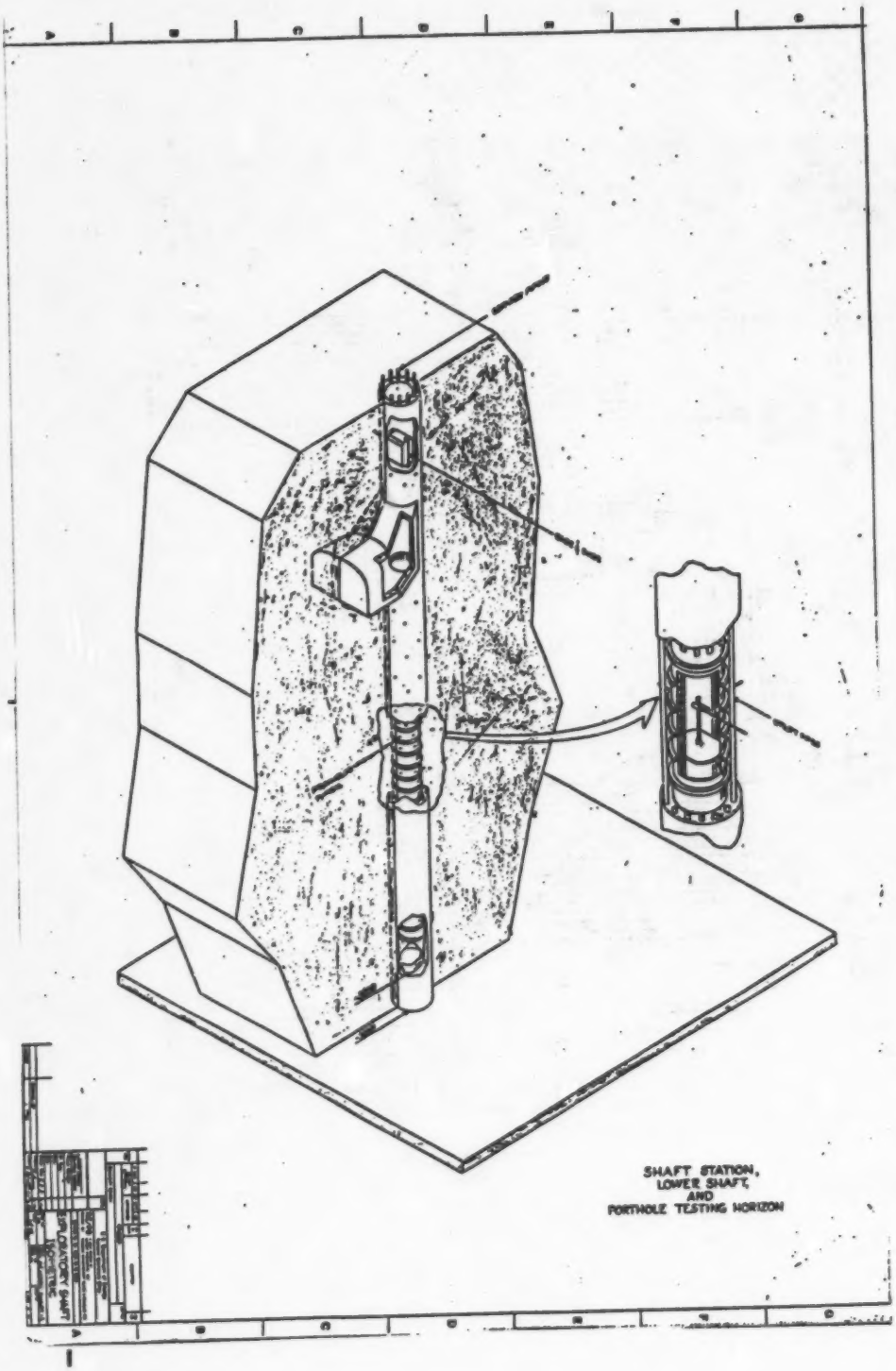

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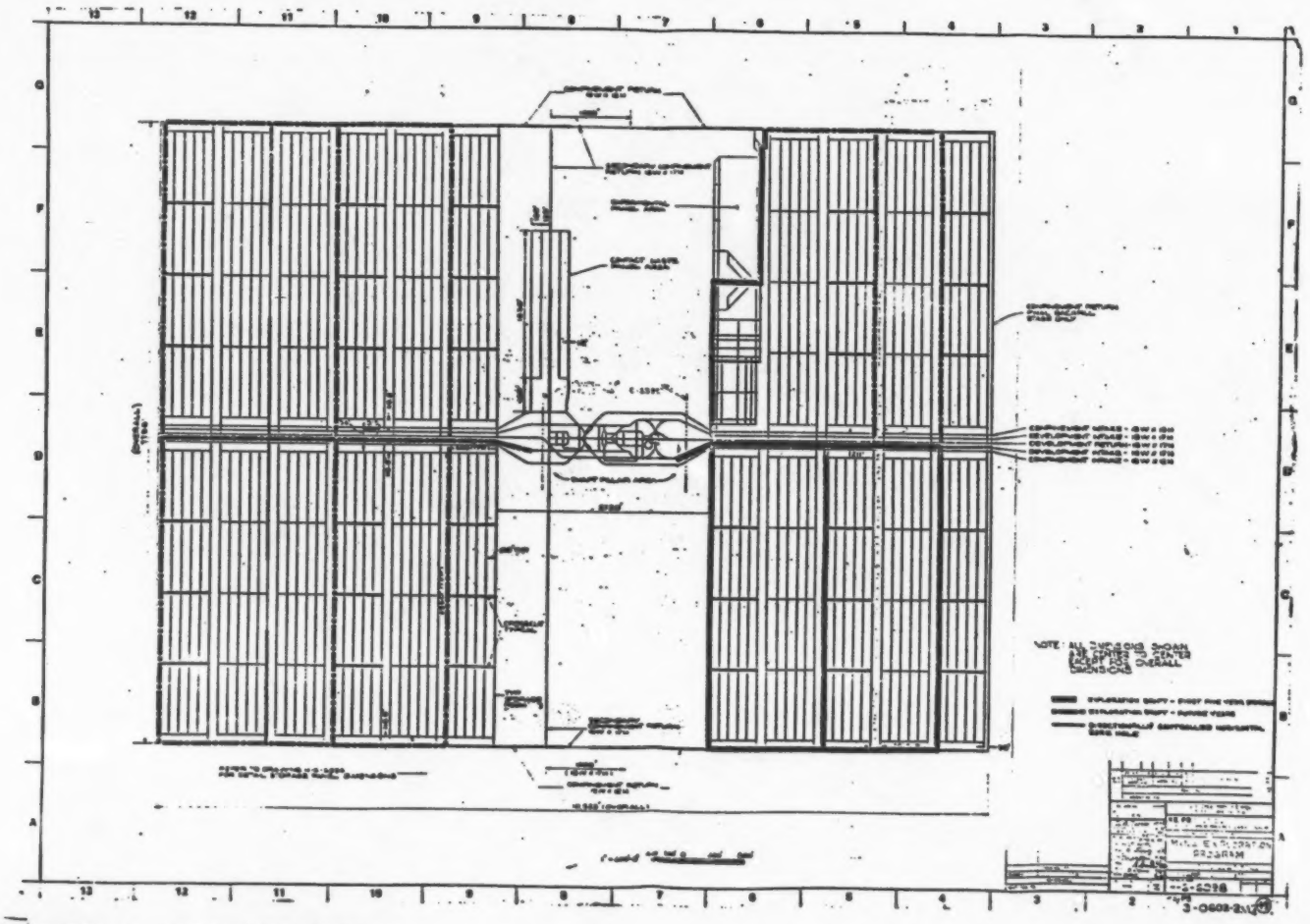

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The exploratory shaft will be sunk at the reference repository location (RRL) to demonstrate construction feasibility, and to provide access to the reference repository horizon for in situ characterization. The exploratory shaft will be 110 in. in diameter drilled to a depth of approximately 3,800 ft, and lined with a 6-ft-ID steel liner with utilities and grout piping attached to the exterior. The annulus will be grout sealed to prevent vertical movement of groundwaters within the shaft. Shaft drilling will provide detailed experience on the suitability of blind hole boring for shaft sinking in basalt.

Tests through portholes from inside the shaft and subsequent shaft breakout into the reference repository horizon will verify the performance of the grout seal and construction-affected zone to safely isolate the reference horizon from the Hanford groundwater system.

Lateral testing through portholes will provide the most accurate and reliable hydrologic data (vertical hydraulic conductivity, head, water chemistry, etc.) to assess the isolation capability of the reference repository horizon. This assessment will provide insight into the suitability of the reference repository horizon for use as a nuclear waste repository.

Geomechanics testing through portholes and during shaft breakout will measure the in situ stresses and detect rock mass movement around the breakout station, and will complete the preliminary characterization of the reference repository horizon. These data are the first step in verifying the constructibility, stability, and safety of underground openings in the reference repository horizon.

At the conclusion of the initial tests mentioned above an extended underground exploration program will be in order.

Safety Considerations

The ES is being designed and constructed in accordance with 30 CFR 57, "Health and Safety Standards--Metal and Non-Metallic Underground Mines", and other applicable safety standards. The ES is considered part of an exploratory program and is not classified as development. All ES activities will be monitored by DOE's Program Manager, Rockwell Hanford Operations, and integrated into general Hanford Site emergency plans.

Design, construction, and operation of ES facilities are planned to prevent or minimize hazards from fires, explosions, human error, and equipment failure, as well as from natural phenomena such as earthquakes and tornados.

Potentially hazardous portions of the surface facilities include diesel storage, explosive storage, electrical systems, and vehicles. Other hazards to personnel include exposure to dust, noise, fumes, and high temperatures. Preventive measures are included in the design by the provision of adequate distances between buildings and clear distances around explosive storage, fire detection and protection systems, and institutional controls.

A number of potential hazards must be considered for the underground operations. These hazards include ground support failures resulting in rock falls, water intrusion, or interruption of services; fire and explosion; service interruptions and equipment failure; falls; and others. These are mitigated by redundancy of all essential systems, protective devices, emergency devices (fire extinguishers, individual self-rescue respirators), palliative devices (dust abatement, filter masks), and monitoring and alarms, as well as by administrative controls and measures.

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SCHEDULE

The time required to adequately explore a site and develop a repository for initial waste storage will necessarily depend upon location, rock type, and depth below the surface. For a typical site a possible schedule would be:

Activity	Years
Exploratory Shaft Construction	1.7- 2.2
Exploratory Shaft Testing	0.5- 0.7
Second Shaft Construction	2.0- 2.6
Underground Exploration and Testing	2.0- 2.6
SUBTOTAL, EXPLORATORY WORK**	6.2- 8.1
Repository Shaft Sinking	5.3- 6.9
Repository Horizontal Work*	2.5- 3.2
SUBTOTAL, REPOSITORY DEVELOPMENT	7.8-10.1
TOTAL UNDERGROUND REPOSITORY WORK	14.0-18.2

* Defined for purposes of this schedule as completion of sufficient space to store five years' receipts of waste and all underground capital facilities.

** Defined as work required prior to start of repository construction.

COST OF MINING ENGINEERING

The cost of mining engineering for a repository should not vary significantly between the different rock types, although each site will have its own particular technical issues to be resolved. The term "mining engineering", as used to develop this estimate includes all engineering involved in the subsurface facilities of a repository and excludes engineering for surface facilities and nondesign-related scientific investigations.

Activity	Man-Hours	Estimated Cost 1982 Dollars
Title I	135,000	$ 5,800,000
Title II	240,000	10,300,000
Title III	256,000	11,000,000
SUBTOTAL	631,000	$27,100,000
Contingency	218,000	8,100,000
TOTAL	849,000	$35,200,000

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NINETY-SEVENTH CONGRESS

MORRIS K. UDALL, ARIZ., CHAIRMAN

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C. 20515

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REPUBLICAN COUNSEL

June 9, 1982

Mr. David Watson
Department Manager
Kaiser Engineers, Inc.
P. O. Box 23210
Oakland, California 94623

Dear Mr. Watson:

The Subcommittee on Energy and the Environment of the Committee on Interior and Insular Affairs has scheduled a hearing Thursday, June 17, 1982, on high-level nuclear waste management issues. I would appreciate your assistance in helping the Subcommittee understand the technical engineering requirements associated with characterization and construction of sites for mined high-level waste repositories.

Specifically, please provide information regarding the following:

-- A description of mining technology, existing and under development, suited or adapted to characterization and development of geologic sites for repositories, and an explanation of this technology in relation to conventional mining technology.

-- Your views regarding appropriate excavations for exploration and characterization of geologic formations for repositories, and appropriate safeguards associated with such construction.

-- An estimate of the amount of time required to complete distinct site characterization and development activities.

-- An estimate of the cost of mining engineering activities.

The Subcommittee requests that 50 copies of your testimony be made available 24 hours prior to the hearing. The hearing will begin at 9:45 a.m. in Room 1324 Longworth House Office Building. Thank you for your assistance.

Sincerely,

MORRIS K. UDALL
Chairman

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STATEMENT OF
KATHLEEN M. BENNETT
ASSISTANT ADMINISTRATOR FOR AIR, NOISE AND RADIATION
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE THE
SUBCOMMITTEE ON ENERGY AND THE ENVIRONMENT
OF THE
COMMITTEE ON INTERIOR AND INSULAR AFFAIRS
HOUSE OF REPRESENTATIVES

JUNE 17, 1982

Mr. Chairman and Members of the Subcommittee, I am pleased to be here to discuss the status of our program to develop environmental standards and radiation protection general criteria for the disposal of high-level radioactive wastes (40 CFR Part 191). Before I begin, it is my pleasure to introduce Glen Sjoblom, who became our new Director of the Office of Radiation Programs last Thursday. I am looking forward to working with Glen as we enter a period of intense activity in developing criteria and standards for radiation protection. Also accompanying me today is Dan Egan, who is the project leader for our high-level waste program.

As you know, the Agency has been working on these standards and general criteria for high-level waste for more than five and one half years. Their development has been both difficult and very different from any other regulatory task we have undertaken. In my testimony today, I will briefly describe our program, and I will then address the five specific topics in which you expressed interest.

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President Reagan's April 28, 1982 message to Congress on nuclear waste disposal reaffirmed the Federal government's responsbility for safe and efficient disposal of nuclear wastes, and it called for a Federally owned and operated permanent repository for disposal of high-level wastes to be available at the earliest practicable date. The environmental protection requirements we are preparing will provide the basic objectives needed to guide development, demonstration and licensing of the methods used to isolate these wastes. As you know, the Nuclear Regulatory Commission (NRC) is developing detailed regulations (10 CFR Part 60) that will implement our requirements, and the Department of Energy (DOE) is responsible for designing, building and operating the Federal repository. We are confident that this national program will provide the safe disposal of high-level wastes that the American people desire.

As currently drafted, our regulatory package for high-level waste disposal includes both numerical performance standards to limit long-term risks to the environment as well as Federal radiation protection general criteria designed to ensure that disposal systems continue to provide protection far into the future. Our performance standards consist of limits on the amount of long-lived radioactivity that can be released to the environment from a disposal system. Our qualitative radiation protection general criteria complement these performance standards by outlining a cautious approach

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for isolating these wastes from the environment for a very long time. For example, our criteria direct use of multiple barriers in designing disposal systems and call for use of sites that do not contain resources likely to attract future exploration.

Current Status. Our standards and general criteria were submitted at the end of last year to the Office of Management and Budget (OMB) for the regulatory impact review required by Executive Order 12291. Although we have been working closely with both OMB and the other Federal agencies to resolve some of the unique questions raised by this package, this review has not been completed yet.

Major Unresolved Issues. During the review under Executive Order 12291, NRC and DOE were asked to provide their views concerning our draft standards and general criteria. Both agencies raised some concerns about specific aspects of the package, and we have worked closed with them to resolve these issues. Although these interactions have taken extra time, they have resulted in significant improvements in our package. I believe this effort has been well spent. Recently, we have reached agreement with both NRC and DOE that our standards and general criteria should be promptly proposed for public review and comment without further changes.

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Funding Commitments. With a regulatory package now ready for proposal, much of our work on this project is already done. From the time we started the effort through the end of FY 1982, we will have expended about 50 staff-years and more than two million dollars of contractual funds to prepare these standards and general criteria and the technical analyses that support them. In addition, we plan to use 13 staff-years and $500,000 of contractual funds to address the comments we receive on our proposal and to make any changes needed in our regulatory package--with the bulk of this future effort programmed for FY 1983.

Promulgation of Final Package. Once we propose our standards and general criteria, we will need a relatively long public comment period, particularly because of the unique issues associated with this package. We plan to hold several public hearings to solicit these comments. During the same period, the Agency's Science Advisory Board will conduct an intensive review of the technical analyses we used to develop our standards. This review will fulfill the commitment the Agency made to this Committee in 1979 to obtain an independent evaluation of our analytical efforts before reaching any final conclusions about the protection provided by these disposal systems. We plan to promulgate our final standards

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and general criteria approximately one year after we propose the package for public review. However, there is a possibility that a somewhat longer period may be needed to evaluate and respond to the comments resulting from these public and technical reviews.

Progress in Absence of a Final EPA Rule. As I noted earlier, President Reagan has called for a permanent repository for high-level wastes to be available at the earliest practicable date. Because our standards and general criteria are an integral part of the national program, we have been closely involved with NRC's development of technical criteria for geologic repositories (10 CFR 60). We believe that NRC's proposed regulation outlines an appropriate and prudent approach for developing geologic repositories, and our close working relationship with NRC has ensured that 10 CFR 60 is consistent with our draft standards and general criteria. Accordingly, NRC's proposed technical criteria should provide the proper framework for DOE's site exploration and technology demonstration programs. Regarding actual licensing actions--when a promulgated 40 CFR 191 will be essential--the first license application for a specific site is not expected in less than five years, and I am confident that our standards and general criteria will be in place well before then.

In closing, I would like to express this Administration's commitment to carrying out the EPA mandate with regard to standards for proper control of radioactive materials. We are vigorously developing several other regulations, including standards for both inactive and active uranium mill tailings and for low-level radioactive wastes. I am particularly pleased with the results of our efforts on the high-level waste standards and general criteria. I am confident that they will provide the foundation for an effective national program for the disposal of high-level radioactive wastes.

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